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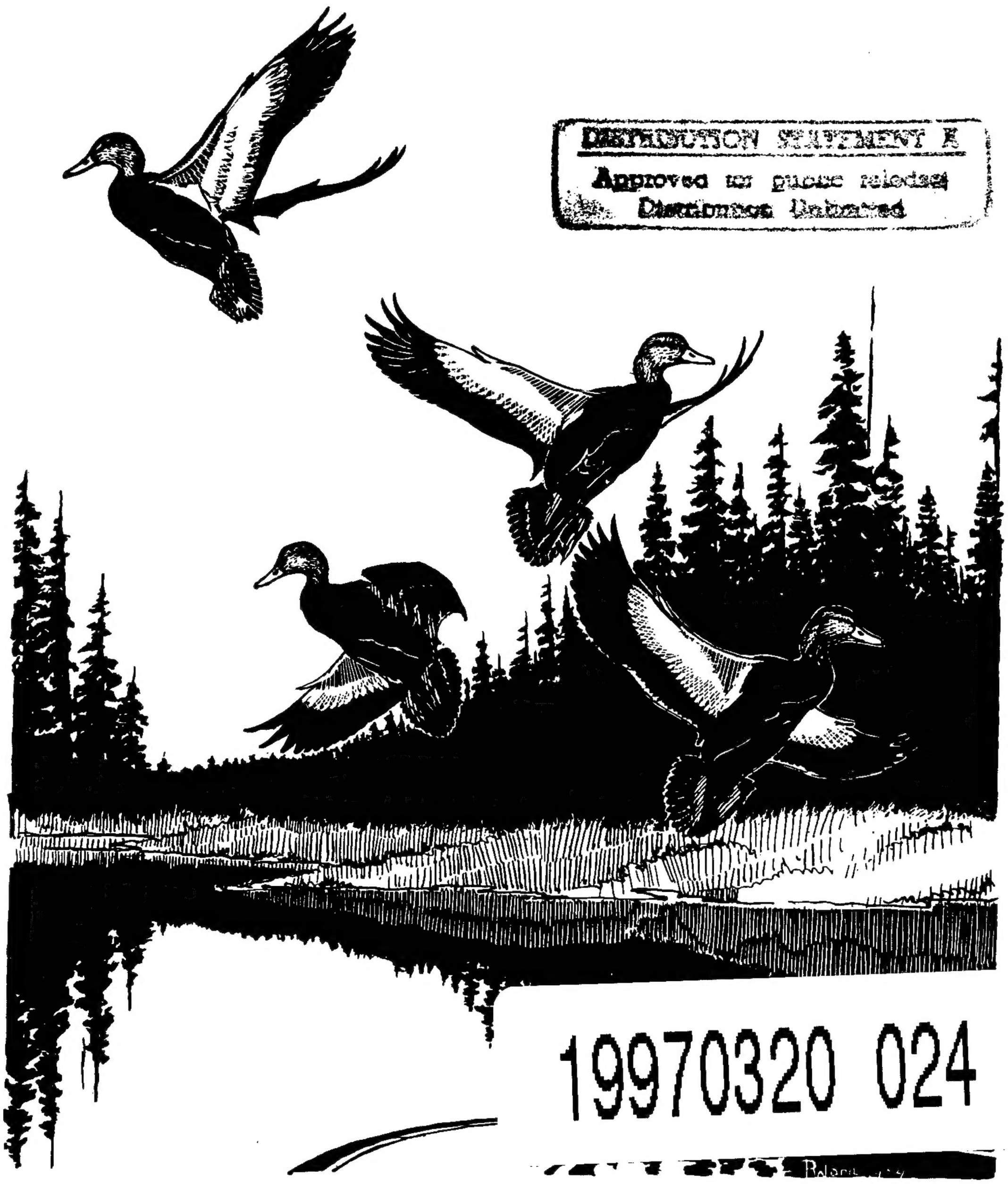
AMERICAN BLACK DUCK BREEDING HABITAT ENHANCEMENT IN THE NORTHEASTERN UNITED STATES: A REVIEW AND SYNTHESIS



Fish and Wildlife Service
U.S. Department of the Interior

The recommendations in this Biological Report are reasonable conclusions drawn from the available literature and numerous personal communications with northeastern waterfowl biologists. There is room for substantial difference of opinion on many of the issues addressed. Thus, this report should be viewed as the author's interpretation and not a formal statement of Fish and Wildlife Service policy on the best means to manage American black ducks in the Northeast. The use of trade names does not constitute endorsement or recommendation for use by the Federal Government.

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American Black Duck Breeding Habitat Enhancement in the Northeastern United States:

A Review and Synthesis

by

Ronald E. Kirby

U.S. Fish and Wildlife Service
Research and Development
Office of Information Transfer
1025 Pennock Place, Suite 212
Fort Collins, CO 80524

Fish and Wildlife Service
U.S. Department of the Interior
Washington, DC 20240

Preface

This review and synthesis was prepared at the request of the Program Committee for the 1987 U.S. Fish and Wildlife Service, Region 5 Refuges and Wildlife Project Leaders' meeting, Wells College, Aurora, NY. The overall purpose was to provide a succinct source document for American black duck management planning throughout the Northeast. In three sections, the text presents highlights of a review of the literature from the perspective of prescribing specific management action for breeding grounds of the American black duck.

The text first reviews what is known of the breeding habitat requirements of American black ducks in the Northeast, with separate sections on use of habitat by pairs, selection of nest sites, and use of habitat by broods. Options for managing American black duck breeding habitat are then discussed under two headings: Habitat Improvement, and Reduction of Mortality and Competition. A final section provides suggestions on implementing management. Sources of additional information are provided, as is an extensive Literature Cited section. The paper is meant to be read from beginning to end so that the logic of some of the management suggestions may be related specifically to the bird's biology.

Much less is known of the subject of this review than one would want at this stage in the history of scientific waterfowl management. Unfortunately, uneasiness about the "absolute truth" of analysis of imperfect or incomplete data all too often is used as a reason to provide no evaluation of available options for wildlife management. Management decisions must and will be made in any case, on either the basis of available information or less valid criteria such as personal opinion or political expediency. Thus, in this review, it is taken as given that lack of conclusions in the literature, consensus among waterfowl biologists, and experimental manipulation of habitat specifically for American black ducks should not be impediments to proposing action.

Scientists and managers should remain skeptical of conclusions in wildlife ecology, and should take every opportunity to test hypotheses and evaluate current management practices—a viewpoint appropriate to this document as well. A starting point for hypothesis formulation and a guide to beginnings in habitat management for breeding American black ducks is provided. What is now needed is the experimentation to evaluate our current state of knowledge.

Comments concerning this document should be addressed to:

Office of Information Transfer
U.S. Fish and Wildlife Service
1025 Pennock Place, Suite 212
Fort Collins, CO 80524

Conversion Table

Metric to U.S. Customary

Multiply	By	To obtain
hectares (ha)	2.471	acres
square kilometers (km^2)	0.3861	square miles
centimeters (cm)	0.3937	inches
meters (m)	3.281	feet
kilometers (km)	0.6214	miles

U.S. Customary to Metric

acres	0.4047	hectares
square miles (mi^2)	2.5901	square kilometers
inches (in.)	2.5400	centimeters
feet (ft)	0.3048	meters
miles (mi)	1.6093	kilometers

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Tables

Acknowledgments

Firsthand experience obtained in American black duck breeding habitats has been graciously facilitated over the years by F. Ferrigno and L.E. Widjeskog in New Jersey; P.O. Corr, J.R. Longcore, J.K. Ringelman, and H.E. Spencer, Jr. in Maine; T.E. Hickey on Prince Edward Island; and W.H. Whitman in New Brunswick. Development of this review was facilitated by recent personal communications received from D.R. Anderson, H. Boyd, P. Dupuis, T.J. Dwyer, G.D. Frazer, S.L. Funderburk, G.M. Haramis, G.L. Hensler, G.W. Kinser, J.R. Longcore, R.S. Palmer, A. Reed, H.M. Reeves, J.K. Ringelman, N.R. Seymour, W.H. Whitman, and L.E. Widjeskog. Thanks especially to J.R. Longcore, J.K. Ringelman, and L.E. Widjeskog for assisting the formulation of some of my assessments. J.R. Longcore, J.K. Ringelman, L.E. Widjeskog, and the Office of Migratory Bird Management are acknowledged for review of drafts of the manuscript.

Appreciation is extended to the Wildlife Management Institute, copyright holder, for permission to reproduce the illustration by Peter Ward from page 59 of Bruce S. Wright's classic review of American black duck biology in the Northeast—*High Tide and an East Wind, The Story of the Black Duck,* published in 1954 by the Stackpole Company, Harrisburg, PA, and the Wildlife Management Institute, Washington, DC. The illustration was also used as the inside back cover of the 1968 symposium on the American black duck edited by P. Barske and sponsored by the Atlantic Flyway Council and others: *The Black Duck, Evaluation, Management, and Research: A Symposium.* Ward's illustration, which closed the 1968 Symposium Proceedings, seemed a fitting cover for this review, two decades later, and 34 years after the publication of Wright's text.

Portions of this report were paraphrased from a manuscript in preparation (R.E. Kirby, P. Dupuis, and G.L. Hensler: Extent and consequences of recent changes in numbers of the American black duck and in hybridization between American black ducks and mallards). G.J. Jackson provided assistance in transferring this text to a new computer system and thereby facilitated completion of the project.

Introduction

The American black duck (*Anas rubripes*[1], hereafter black duck) is the northeastern North American counterpart of its close relative, the mallard (*Anas platyrhynchos*). Its breeding range is the only appreciable gap in the breeding range of the mallard in the north temperate zone: mainly northward from latitude 40° N and eastward from about the Mississippi River with some breeding populations as far south as the Atlantic coast of North Carolina (Stewart 1958).

Concern about the distribution and numbers of the black duck has existed since the turn of the century. Phillips (1923) commented on a marked increase of black ducks following the cessation of spring shooting in New England in 1908. Stone (1937) made similar observations in New Jersey. Bent (1923) proposed that the species was not in need of any particularly stringent protective laws because of its innate wariness, the existence of numerous refuges, and the supposed accommodation of the black duck to high human densities. By the late 1940's, however, the situation had changed, leading Gabrielson (1947) to warn that the black duck was at its most precarious position to date. Eastern waterfowl biologists, alarmed by apparent downward trends in black duck numbers, held a symposium on the species' problems in the late 1960's (Barske 1968) and again in 1973 (Atlantic Waterfowl Council et al. 1973).

In an effort to stabilize or increase black duck numbers, extensive international banding programs and hunting regulations have been promulgated by the United States and Canada. A species management plan has been developed (Spencer 1980) and substantial new research and expanded population monitoring programs have been developed in Canada and the United States as a result of implementation of aspects of the North American Waterfowl Management Plan (Canadian Wildlife Service and U.S. Fish and Wildlife Service 1986). The species has been the subject of steadily increasing attention through technical reviews (e.g., Belanger 1984, 1986; Rogers and Patterson 1984; Spencer 1981, 1986) and litigation regarding management action (Grandy 1983; Feierabend 1984), and continues to be the subject of research in Provincial, State, Canadian Wildlife Service, U.S. Fish and Wildlife Service, University, and private organizations.

The loss and degradation of waterfowl habitat has been identified in the North American Waterfowl Management Plan as the major waterfowl management problem in North America (Canadian Wildlife Service and U.S. Fish and Wildlife Service 1986). Black duck habitat in the unaltered, natural environments along the Great Lakes-St. Lawrence lowlands, boreal forest, and Atlantic coastal lowlands and estuaries are all increasingly threatened by agriculture, urbanization, water control and forestry projects, industrial development, and pollution. Thus, one of the habitat management goals in the North American Waterfowl Management Plan relates specifically to the black duck:

[1] Scientific and English common names of all plants and animals mentioned in the text are listed in the Appendix,

"To protect 60,000 additional acres of breeding and migration habitat in the Great Lakes-St. Lawrence lowlands for black ducks and other waterfowl in Canada and 10,000 additional acres in the United States."

Similarly, an additional goal enhancing migration and wintering habitat, which calls for improving habitat quality throughout and effecting a 25% increase in carrying capacity on 382,500 acres of land managed for waterfowl by wildlife agencies, will also benefit the southern portion of the breeding range of the black duck. Likewise, the Atlantic Waterfowl Council habitat management plan for the species (Spencer 1980) calls for increasing productivity through habitat preservation and management. These goals all suggest concentration on best management practices for high-quality black duck habitat throughout the species' breeding range. The sum of these efforts is intended to meet the North American Waterfowl Management Plan goal of attaining by the year 2000 a wintering population index of 385,000 black ducks in the Atlantic and Mississippi flyways.

In response to these overall objectives and specific requests for implementation by the Fish and Wildlife Service Director, the Service's Northeast Region is emphasizing efficient management of black duck breeding habitat on National Wildlife Refuges. Guidelines for such activity are lacking, as is any succinct account of the characteristics of black duck breeding habitat per se. Thus, this *Biological Report* has been prepared as a review for use in preparing habitat management plans on Refuges and similar lands. Evaluated herein is the literature on black duck breeding habitat, and the pros and cons of various management alternatives for black duck breeding habitat in the eastern United States. This document is not a "manual" for waterfowl management, but sufficient references are included to permit further review of all aspects of black duck breeding ecology and each of the management techniques addressed.

Habitat Use During the Breeding Season

Detailed studies of breeding black ducks are limited (Table 1), and only the most recent studies in Ohio, Maine, and the Maritime Provinces emphasize quantitative assessment of behavior, habitat use, and population dynamics. Substantial additional data have been collected in a long-running series of investigations by the Canadian Wildlife Service which emphasized broad-scale surveys, evaluation of survey methods, and range-wide population assessment. Results of these studies recently have been collected in three summary publications (Boyd 1974; Curtis et al. 1984; Erskine 1987*d*).

Black ducks can be found on salt, brackish, and fresh water, and may be found in far northern boreal forest (and perhaps onto the tundra), agricultural lands, urban and suburban parklands, and coastal and inland wetlands of all types as well as at sea beyond the breakers when disturbed by man. Habitats used include estuaries; tidal marshes, ledges, and flats; freshwater streams; inland lakes and reservoirs; and small woodland pools. During the breeding season, this species makes greater use of wooded habitat than other *Anas*, but such a wide range of habitats is used that Palmer (1976) characterized breeding habitats and nest sites as "so diverse that the presence of water, no matter how restricted, is virtually the only characteristic in common." More recent work has shown that this may be an inappropriate generalization, for black duck nests may be more than a kilometer from water (Ringelman et al. 1982).

Breeding Densities

It has been difficult to obtain reliable estimates of black duck breeding density over large areas, especially in boreal forest, because of the inefficiency of large-scale aerial (Chamberlain and Kaczynski 1965) or ground (Whitman 1987) surveys. Two early surveys did, however, attempt continent-wide assessment. Stewart (1958) estimated black duck breeding densities from aerial transect data by ecoregion as: $0.17–0.19/km^2$ in Hemlock-White Pine-Northern Hardwood Forest; $0.10–0.13/km^2$ in Maine Boreal Forest; and $0.10–0.11/km^2$ in Open Boreal Woodland and Forest–Tundra. In later exploratory aerial surveys of the boreal forest of Quebec and Ontario, Kaczynski and Chamberlain (1968) observed 0.103 black ducks/km^2 which, when

Table 1. *Studies of breeding American black ducks reported in the literature.*

Location	Reference
North Carolina	Parnell and Quay (1962)
Chesapeake Bay, Maryland	Stotts (1955, 1956, 1968, 1987)
	Stotts and Davis (1960)
South coastal New Jersey	Ferrigno (1964)
	Gavutis (1967)
Ohio	Trautman (1947, 1949)
	Barclay (1970)
Northwestern New York	Benson (1937)
Northeastern United States	Coulter and Mendall (1968)
Northern New England	Coulter and Miller (1968)
Maine	Mendall (1949*a*,*b*, 1958)
	Coulter (1955)
	Spencer (1957)
Southcentral Maine	Reinecke (1977, 1979)
	Reinecke and Owen (1980)
	Reinecke et al. (1982)
	Ringelman (1980)
	Ringelman and Longcore (1982*a*,*b*, 1983)
	Ringelman et al. (1982)
New Hampshire	Nevers (1968*a*,*b*)
Ontario	Laperle (1974)
	Patterson (1972, 1976)
St. Lawrence estuary, Quebec	Reed (1964, 1968, 1970, 1973*a*,*b*, 1975)
Quebec and Maritimes	Wright (1947, 1954)
	Courcelles (1978)
	Courcelles and Bedard (1979)
New Brunswick	Renouf (1970, 1972)
	Whitman (1973, 1976, 1987)
Nova Scotia (freshwater)	Hughson (1971)
	Seymour (1977, 1984)
	Seymour and Titman (1978, 1979)
Nova Scotia (tidal marsh)	Seymour (1977)
	Seymour and Titman (1978, 1979)
Prince Edward Island	Hickey (1980)
	Hickey and Titman (1983)

adjusted for their calculated visibility rate of 0.16–0.21, yielded an estimate of 0.490 to 0.643 black ducks/km^2. More refined estimates, based on the Canada Land Inventory and estimates of waterfowl density for each Land Capability Class, suggest black duck densities of 0.57/km^2 in Nova Scotia, 1.34/km^2 in Prince Edward Island, 0.67/km^2 in New Brunswick, 0.35/km^2 in Newfoundland (island), and 0.13/km^2 in Labrador (calculated from Erskine 1987*a*). Black duck breeding densities in a major portion of its range are much lower than those of other species of dabbling ducks elsewhere in North America.

In Canada, the greatest black duck densities are generally found in the mixed forests of the Great Lakes-St. Lawrence and Acadian Forest regions (Reed 1968). In the United States, greatest densities have been recorded in coastal marshes. Munro (1968) and Reed (1968) felt that data were insufficient two decades ago to

compare breeding densities for specific habitats in various portions of the black duck's range. This still appears to be a valid assessment, but a representative sample of recorded breeding densities provides an estimate of the range of values to be expected in habitats similar to those for which quantitative data are available (Tables 2 and 3). Islands and managed marshes are habitats with highest recorded densities of breeding pairs, but in the spring the majority of the species is spread at low densities through wide expanses of habitat.

Pair Habitat

Wright (1954) suggested that any area with water and freedom from interference by man was satisfactory habitat for black duck pairs. Representative studies (Table 4) show that wetlands—from the coast to small inland freshwater pools, streams, and rivers as well as managed marshes and large river systems—provide habitat that pairs require. The available studies of pairs in inland habitat in Ohio and Maine (Barclay 1970 and Ringelman et al. 1982, respectively); coastal marshes (Seymour and Titman 1978, 1979) and inland streams in Nova Scotia (Seymour 1984); the St. Lawrence, Quebec (Reed 1970); the St. John River, New Brunswick (Wright 1947, 1954); and the Chesapeake Bay, Maryland (Stotts 1955; Stotts and Davis 1960; Stotts 1987) present a bewildering array of information on black duck habitat choice, spacing of pairs, and chronology and phenology of use of habitat in the spring. This is partially an artifact of these studies being investigations of areas so intrinsically different that only a few direct habitat parallels can be drawn. Nonetheless, black duck pairs appear to be behaving similarly in these habitats and some generalities on pair habitat requirements can be identified.

Initial Habitat Selection

Habitat use by breeding pairs reflects both preference by the birds and the availability of different wetland types (Ringelman et al. 1982). The structure and diversity of the vegetation, rather than its species composition, seem to be the proximate factors used by black ducks in the selection of wetlands (Ringelman 1980). Reed (1970) proposed that birds are probably initially attracted to an area by preferred nesting cover. Good brood-rearing and feeding areas near nesting cover also may serve as an attractant, but in a secondary sense, and previous experience of the female may affect exact choice of nesting cover.

Black ducks may return to breeding areas before wetlands are ice-free if rain and meltwater accumulate on ice surfaces. Breeding pairs can always be found on wetlands as soon as they are ice-free, with resident pairs often in place before all birds returning to higher latitudes have migrated or wintering flocks in nearby areas have dispersed. Thus, it is the conditions in very early spring that are critical to choice of an area by a breeding pair. Homing to the vicinity of previous nest sites by black ducks has been documented by Coulter and Miller (1968), Reed (1970), and Ringelman et al. (1982), and appears similar to that recorded for other dabbling ducks.

Territoriality and Home Range

Territoriality in black ducks is difficult to appraise because of difficulty in observing the birds and the dispersed and noncontiguous nature of many home ranges. Wright (1947) suggested that territoriality differed in the eastern portion of the black duck's range from that of the West, and Trautman (1947) and Mendall (1958) commented on the extreme variability of the species' territorial behavior. Despite this early emphasis on the variability of territorial behavior—and even suggestions it was lacking in the species—a fairly typical dabbling duck pattern of home range establishment and defense seems to exist, although territorial behavior may not be particularly evident in some habitats. Only a few good estimates of black duck home range are available (Table 5).

Reed (1970) identified three types of breeding habitat used by black ducks in the St. Lawrence and was able to quantify some distances traveled:

- Island nesters fed and loafed mainly in the tidal marsh and used an island communally for

Table 2. *Representative population densities of breeding American black ducks in Canada and the United States reported in the literature.*

Habitat	Number of breeding pairs per ha	Source
Labrador		
Southeastern	0.002	Goudie and Whitman (1987)
Lake Plateau	0.003	Gillespie and Wetmore (1974)
Maine		
impounded marsh	0.494[a]	Mendall (1949*a*)
bog and sedge meadow	0.062-0.123	Coulter and Mendall (1968)
sedge-bog	0.082	Coulter and Miller (1968)
Maryland		
Bodkin Island, Chesapeake Bay	8.9	Stotts (1956)
New Brunswick	0.14, 0.20	Erskine (1987*e*)
	0.035	Wright (1947)
New York		
Fire Island marshes	0.309	Benson (1968)
typical upland habitat	0.111	Benson (1968)
beaver pond	0.148	Benson (1968)
Nova Scotia		
estuarine marsh	0.039	Seymour and Titman (1978)
Cape Breton Island		Erskine (1987*c*)
freshwater	0.23	
brackish non-tidal	0.12	
brackish tidal	0.08	
Ohio		
Winous Point	0.033	Andrews (1952)
	0.028	Bandy (1965)
	0.033	Barclay (1970)
Ontario		
Southern	0.003	Dennis (1974*a*)
Clay Belt	0.0031	Dennis (1974*b*)
Precambrian Shield	0.0028	Dennis (1974*b*)
Northwestern	0.0007	Dennis and North (1984*a*)
Northwestern	0.0011	Boyd (1984)
Quebec		
Baie Noire Marsh		Courcelles and Bedard (1979)
open cattail	0.72-1.83	
semi-open, stumps, burreed	0.07-0.14	
few aquatics and stumps	0.28-0.4	
deep water	0.01-0.06	
St. Lawrence		Reed (1970)
lowland on mainland	0.005	
upland on mainland	0.002	
Ile aux Pommes (island)	1.58	

[a]Following intensive management. Densities before management never exceeded 0.141 birds/ha.

Table 3. *Additional estimates of American black duck breeding density using several scales of measure.*

Habitat	Density	Source
Maine	25-30 pairs/38 km^2 with 20 wetlands	Spencer (1963)
Maryland		
Kent Island	27.4 birds/km shoreline	Stotts (1959)
brackish marsh	3.2 pairs/km shoreline	Stotts (1968)
saline marsh	0.9 pairs/km shoreline	Stotts (1968)
Kent, Queen Anne's, and Talbot counties	4.7 pairs/km shoreline	Stotts (1987)
Newfoundland		Goudie (1987)
Avalon Boreal Forest	243-343 pairs/100 km^2	
Central Forest	130-287 pairs/100 km^2	
Maritime Barrens	62-70 pairs/100 km^2	
Western Forest	57 pairs/100 km^2	
North Shore	31 pairs/100 km^2	
Northern Peninsula	122 pairs/100 km^2	
Long Range Barrens	22 pairs/100 km^2	

Table 4. *Representative American black duck pair habitat reported in the literature.*

Habitat	Location	Source
Persistent emergent[a] Broad-leaved deciduous forest Broad-leaved deciduous scrub-shrub Ephemeral pools Streams	Inland Maine	Ringelman et al. (1982)
River floodplain	New Brunswick	Wright (1954)
Beaver ponds	New Hampshire	Nevers (1968*a*,*b*)
Estuarine marsh (especially permanent ponds and inlets)	Nova Scotia	Seymour and Titman (1978)
Rivers and streams		Seymour (1984)
Diked fresh marsh	Ohio	Barclay (1970)
Inland tidal and fresh waters	Prince Edward Island	Hickey (1980)
Tidal marsh	St. Lawrence, Quebec	Reed (1970)

[a]Wetland vegetation types from Cowardin et al. (1979).

Table 5. *American black duck home ranges reported in the literature.*[a]

Size (ha)	Habitat	Location	Source
119 (female)	Inland forest-wetlands	Maine	Ringelman et al. (1982)
231 (male)			
3.8	Winous Point fresh marsh	Ohio	Barclay (1970)
<13	Islands and fresh marsh	Maine, Vermont	Coulter and Miller (1968)

[a]Not obtained with comparable techniques. Ringelman et al. (1982) was a telemetry study, Barclay's (1970) data refer to "activity centers" identified by observation of marked birds, and Coulter and Miller (1968) studied marked birds.

nesting and only to a limited extent for loafing and feeding. The two portions of the home range were from 5.6 km to 8.0 km apart.

- Upland nesters also fed and loafed mainly in the tidal marsh. Large areas surrounding the upland nest sites were occupied and defended from other pairs. The two portions of the home range were separated by between 0.2 and 1.2 km.
- Lowland nesters fed and loafed in the tidal marsh and established exclusive areas in the marsh immediately adjacent to, and often including, the nest site.

These generalizations, although derived only from studies in the St. Lawrence, appear to apply to the species throughout its range with one addition: Ringelman et al. (1982) found that black ducks nesting in forested areas (1) used a small set of wetlands exclusively, (2) that the size of the defended area varied among birds and depended on the wetland occupied at the time of encounter with a conspecific, and (3) that territory size varied with the optical density of the wetland vegetation, defended areas in more open habitat being larger.

Studies from elsewhere in the black duck's range confirm these generalizations on habitat use by pairs. Seymour and Titman (1978) found estuarine birds in Nova Scotia occupying territories on a pond or section of marsh edge from which the female initiated "exploratory flights" into nesting cover; ponds were defended "assiduously." Birds using streams and rivers adjacent to this estuary still fed on the estuary, but males defended areas along the rivers 7–10 days before females began laying, and habitat similar to estuarine ponds was selected (Seymour 1984). Stotts and Davis (1960) found frequency of territorial defense low in Chesapeake Bay, but males did react to conspecifics. In Nova Scotia and Chesapeake Bay, communal areas were used for feeding, but in Maine, the birds stayed in their territories throughout each 24 h.

What are the benefits of expending the energy to establish and defend an area from conspecifics? In some habitats, a reliable and secluded feeding area appears to be provided by territorial defense. This seems to apply to some estuarine birds (Seymour and Titman 1978) and those nesting near small inland wetlands (Ringelman 1980). It is important to note that in many habitats it is difficult to identify the specific resources for which black duck pairs compete even though competition for space (e.g., pursuit flights; see McKinney 1965) can be observed. It is likely that resources per se may not be the basis of territorial defense in many circumstances, but the reproductive output of both the male and female is nonetheless favored by territorial behavior (N.R. Seymour, personal communication). This is because territorial behavior also reflects the male's attempts to prevent copulation with his mate by other birds and is one means of assuring that the pair remain together during the prelaying and laying period. Also, seclusion provided by this spacing provides the pair with more

opportunity for undisturbed foraging, resting, and copulation, and provides cover for the female when flying to and from the nest. Spacing also has the added effect of dispersing nests which reduces the probability of predation of any particular nest (McKinney 1965).

Two aspects of habitat use seem critical for management of pair habitat. The first is that there can be a lack of available space for pairs in some habitats and thus an upper limit to the density attainable. For example, Mendall (1949*b*) found that black duck use of Moosehorn National Wildlife Refuge in Maine could not be increased until the wetlands were modified to provide additional habitat in which pairs could be secluded. Second, black duck females require high quality feeding areas to permit development of eggs, and will use such areas communally, if necessary, in estuarine habitat, but otherwise pairs aggressively exclude conspecifics. This suggests that management of pair habitat must consider not only the attributes of cover and space, but also the necessary provision of other resources needed by females during the breeding season. In general, for reasons of energetic efficiency, black ducks appear to use the smallest home range possible that will provide all requisites (Ringelman et al. 1982).

Nesting Habitat

Local requirements for a nest site are (1) concealing cover, (2) some kind of substrate (e.g., ground litter), and (3) a location near a change or "break" in cover (Coulter and Miller 1968). In general, the habitat used for nesting by black ducks parallels the range in habitat used by pairs (Table 3) and encompasses the complete range of upland and lowland habitats available in the Northeast. But when more specific data are tabulated—that is, the habitat at the nest proper (Table 6)—such a diverse picture emerges that simple inspection of the data will not permit generalizations. Similarly, a wide array of nest densities has been reported in the literature (Table 7) with extreme densities reported for small predator-free islands and lower densities in mainland marsh and upland sites.

Although a wide variety of sites is used by black ducks for nesting, including ones that are rather unusual for dabbling ducks, the general preference seems to be to construct ground nests as do other *Anas*. In cases where local populations have a high frequency of use of tree and stump nests, inspection of the habitat usually reveals either high risk of predation of ground nests, high probability of flooding of ground nests, or a combination of the two. Laperle's (1974) data clearly trace the development of the tree nesting habit in an area subject to extreme water level fluctuations, and studies in other areas with similarly unpredictable spring hydrologic regimes provide similar data (Wright 1954; Prince 1968).

Young (1968) suggested that black ducks preferred islands for nesting, but, as emphasized by Coulter and Miller (1968) and Reed (1970), islands seem to be selected only when marsh and other sites are unavailable. The absence of mammalian predators and the presence of breeding gulls (Vermeer 1968) seems to facilitate acceptance of island sites. In the best known island nesting population, that of Ile aux Pommes in the St. Lawrence, certain features of the islands (isolated land mass, grassy cover, presence of gulls) attracted a disproportionately large number of black ducks from a large population that was supported by a nearby marsh (Reed 1973*a*). Similar observations have been made on islands in freshwater habitat. Coulter and Miller (1968) listed absence of mammalian predators; large amounts of high quality concealing cover; low degree of human disturbance during April, May, June, and probably July; and low levels of direct or indirect human disturbance of the islands' vegetation at all seasons as factors critical to the use of islands by nesting black ducks in northern New England. Nonetheless, they emphasized that the birds would select sedge-meadow cover for nesting if it were available, despite the apparent attractiveness of some islands.

Similar comments apply to use of offshore duck blinds as nest sites for black ducks. Although Stotts (1958) provided specific management advice for modifying duck blinds to increase black duck nesting success, blinds appeared to be most used when nearby shores

Table 6. *American black duck nesting habitat in Canada and the United States.*

Location	Habitat[a]	Source
Goose River, Maine	sedge-meadow bogs (leatherleaf, sweetgale, and shrubs)	Coulter and Miller (1968)
Maine and Vermont	wooded islands (under trees and dead herbaceous vegetation early; new herbaceous growth later; tree crotches and hollow stubs)	Coulter and Miller (1968)
Pea Island, North Carolina	thin marshhay cordgrass	Parnell and Quay (1962)
Chesapeake Bay	offshore duck blinds	Stotts (1958)
Kent Island	upland areas (65%) (Japanese honeysuckle; poison ivy; brush piles; tree bases)	Stotts and Davis (1960)
	marshes (17%) (seashore saltgrass; cordgrass; panicum)	
	duck blinds (19%)	
	cultivated fields (4%)	
	uncultivated borders (2%)	
	in trees ($n = 4$)	
	in common grackle nest ($n = 1$)	
	in great blue heron nest ($n = 3$)	
brackish estuary	smooth cordgrass ($n = 7$)	
	marshhay cordgrass ($n = 2$)	
	Olney bulrush-marshhay cordgrass ($n = 2$)	
	smooth cordgrass-shrubs ($n = 2$)	
	needle rush ($n = 1$)	
	grass ($n = 1$)	
	coastal and estuarine embayed areas and uplands ($n = 14$)	
Blackwater NWR	islands and high marsh border	Van Huizen (1932)
Maine	herbaceous cover and under fallen trees on islands	Gross (1945)
	wetland edge, hummocks, islands—herbaceous or shrub vegetation ($n = 7$)	Ringelman et al. (1982)
	uplands beneath trees and slash ($n = 4$)	
Michigan	muskrat houses; sedge tussocks; jack pine forest	Pirnie (1935)
New Jersey		
uplands	base of trees and beneath shrubs in hardwood forest slightly above 2-yr floodplain	L.E. Widjeskog (personal communication)

[a]Scientific names of plants and animals mentioned are presented in the Appendix.

coastal	high spots in marshhay cordgrass marsh; on dikes; in tall smooth cordgrass late in year	
Brigantine NWR	marshhay cordgrass islands and clumps (50%); mounds in smooth cordgrass	Gavutis (1967)
Nova Scotia	freshwater marsh	Seymour (1984)
New Brunswick		
St. John River	tops of ridges to flooded lowlands; tree cavities and on ground	Wright (1948)
	floodplain tree cavities	Prince (1968)
western	tussock in low spruces	Erskine (1987*e*)
New York	abandoned osprey nest	Bull (1974)
Montezuma NWR	stump and tree nests	Cowardin et al. (1967)
Sudbury, Ontario	islands (base of trees; small bushes; brush piles; old boat; blueberry; leatherleaf)	Young (1968)
	floating bog (leatherleaf; sedge and grass)	
	lakeshore (jack pine windfall)	
	upland woods (blueberry bush)	
	peninsula (grass)	
	artificial nesting rafts	
Winous Point, Ohio	dikes (40%)	Barclay (1970)
	nest structures (40%)	
	muskrat lodges (13%)	
	wet meadow (7%)	
Quebec		
Lake St. Louis	trees during flood	Laperle (1974)
St. Lawrence		
offshore islands	grass (n = 404)	Reed (1964, 1968, 1970, 1975)
	forest (n = 24)	
Ile aux Pommes	grass (n = 247)	Reed (1968)
	shrub and tree (n = 63)	
	rock crevice (n = 5)	
	artificial (n = 7)	
mainland	forest (n = 2)	
	agricultural lands (n = 11)	
	fallow and peat bog (n = 17)	
	marsh above mean high water (n = 28)	
	tidal marsh (n = 2)	
	grass (n = 14)	
	shrub and tree (n = 7)	
	brush pile (n = 1)	

Table 7. *American black duck nest density in various habitats.*

Location	Density (number per ha)	Source
Brackish estuarine marsh, Dorchester Co., Maryland	0.13	Stewart and Robbins (1958)
Mainland near Chesapeake Bay, Maryland	0.0-3.6	Stotts (1987)
Uplands, Bodkin Island, Maryland	234.8	Stotts (1987)
Marsh, Chesapeake Bay	0.39-15.00	Stotts (1987)
Chesapeake Bay islands, Maryland	1.48-52.87	Stotts (1960)
No Man's Land, Maine	7.4	Gross (1945)
Maine and southwestern New Brunswick	0.06-0.12	Coulter and Miller (1968)
Maine and Vermont (wooded islands)	4.32-12.57	Coulter and Miller (1968)
Iles-de-la-Paix, Quebec (14 islands)	0.10-0.41	Laperle (1974)
Ile aux Pommes, Quebec (island in St. Lawrence)	2.36-11.78	Reed (1975)
St. John River Valley, New Brunswick	0.37	Wright (1954)
Impounded coastal marsh (Brigantine NWR), New Jersey	2.72	Gavutis (1967)

were unsuitable for nesting (high banks eroding beaches, agricultural lands, suburban development, etc.).

Reed (1973*b*) listed two basic factors governing the choice of the nest site that seem to apply to the black duck throughout its range: minimizing the risk of predation on the eggs and female and the risk of flooding the nest, and providing duckling feeding areas close enough for young to traverse the distance on stored yolk reserves. Black ducks achieve good nest success by widely spacing nests (except in certain circumstances such as on islands), by using "hidden" locations for the nest, and by making themselves inconspicuous during nesting. Management action to augment each of these natural characteristics is the best scheme for habitat management for nesting black ducks. This management should also recognize that when off the nest, black duck females use wetlands ranging from <30 m to >1,900 m from the nest site (data from southcentral Maine; Ringelman et al. 1982).

Brood-rearing Habitat

Migrational homing by adult and yearling females and subsequent successful rearing of

broods maintains and augments a population over time. Thus, availability of appropriate brood–rearing habitat cannot be separated from the black duck's need for appropriate pair and nesting habitat. Saunders (1926) and Spencer (1968) emphasized that a mixture of habitats was necessary for successful reproduction and that there were differences in habitat choice between pairs and females with broods. Telemetry studies have confirmed these differences in habitat selection (e.g., Ringelman and Longcore 1982*a*; Ringelman et al. 1982) and the selection of specific wetland for certain activities instead of use of wetlands in proportion to their availability. Females will not hesitate to take broods long distances to reach appropriate habitat. Overland travel to reach quality wetlands (Young 1967; Ringelman and Longcore 1982*a,b*), and long over-water excursions (Leopold 1951) presumably confer a survival advantage despite the mortality often associated with such moves. Perhaps a maximum in potential danger is incurred on Ile aux Pommes by ducklings which swim 5.9 km to the mainland immediately after they hatch (Reed 1968). Documented inland moves are shorter; for example, 1.2 km in southcentral Maine (Ringelman and Longcore 1982*a*) and approximately 3.2 km in New Brunswick (Wright 1954).

Reports of brood-rearing habitat in the literature encompass the range of habitats used by the species (Table 8). All authors emphasized the value of highly productive waters to broods, and the necessity for concealing vegetation in the brood habitat. Food for downy and partially feathered juvenile black ducks in inland Maine averaged 88% and 91% aquatic invertebrates (dry weight) respectively, but decreased to 43% for fully feathered young (Reinecke 1979). Mendall (1949*a*) found that the only plant foods of importance to downy ducklings were annual wildrice (*Zizania aquatica*), pondweeds (*Potamogeton* spp.), and naiads (*Najas* spp.). Herbaceous vegetation supports a higher biomass of invertebrates than any other life form (Reinecke 1977), and it is to these invertebrate-rich patches that females lead their broods in freshwater wetlands. In the St. Lawrence salt marshes, young broods make intensive use of the upper marsh marshhay cordgrass (*Spartina patens*) and rush (*Juncus* spp.) slope, spending almost all of their time around widgeongrass (*Ruppia maritima*) pools. Later, they extend their movements seaward and use the lower smooth cordgrass (*S. alterniflora*) zone as well (Reed 1968). The reasons for this concentration on the tidal and shoreline marsh is the abundance of invertebrates supported by the high productivity of the coastal marsh supplemented by the edge effect of the *Ruppia* pools and the presence of concealing vegetation (Reed and Moisan 1971). On the coast of Nova Scotia, broods from the coastal marshes as well as inland areas also concentrate in coastal marsh to take advantage of the highly productive estuarine food supply (Seymour 1977, 1984).

It is clear that brood habitat for black ducks must contain sufficient structure to provide cover and sufficient aquatic invertebrates to provide the protein-rich foods needed for growth and development. Habitats consistently meeting these requirements include all tidal marshes, new impoundments, and active beaver (*Castor canadensis*) flowages 1 to 5 years old.

Options for Management of Breeding Habitat

The prior discussion has presented black duck breeding ecology as three intimately interrelated sets of habitat requirements necessary first to pairs, then to the nesting female, and finally to the brood of ducklings. Black duck production will falter if weaknesses are present at any level of this seasonal chain of habitat requirements. From the management standpoint, then, it is imperative that a holistic approach to managing black duck habitat be accepted: all necessary habitats must be available in appropriate quantity and quality or the weak portions will limit success. Similarly, but beyond the scope of this review, postbreeding and wintering habitat also should be considered a continuum of the habitat needs of the species during the breeding period, especially for local populations with little or no migratory movement.

Management to benefit breeding black ducks can be generally divided into two categories: habitat improvement, and reduction of

Table 8. *American black duck brood-rearing habitat in Canada and the United States.*

Location	Habitat	Source
Connecticut	sedge-shrub marsh wooded swamp tidal marsh	Coulter and Mendall (1968)
Pea Island, North Carolina	flooded edges of freshwater ponds shallow salt marsh sloughs and creeks	Parnell and Quay (1962)
Bodie Island, North Carolina	brackish ponds borrow pits	Parnell and Quay (1962)
New York	beaver ponds emergent wetlands	Benson (1937)
inland Maine	emergent and deciduous scrub shrub wetlands affected by beaver beaver flowages	Ringelman and Longcore (1982*a*) Spencer (1957)
New Hampshire	new beaver ponds fresh marsh, beaver beaver flowages shallow ponds	Nevers (1968*a*) Coulter and Mendall (1968)
Vermont	flooded hardwoods with forest-shrub border, especially beaver flowages	Coulter and Mendall (1968)
Nova Scotia	estuarine marsh freshwater streams inland fresh marsh	Seymour (1984) Seymour (1984) Hughson (1971)
Prince Edward Island	inland fresh marsh inland fresh marsh brackish streams and ponds	Hickey (1980) Bartlett (1987)
Ile aux Pommes, Quebec	tidal marsh (St. Lawrence)	Reed (1975)

mortality factors and competition. The two are not mutually exclusive, but it is convenient to consider them separately, because the first must be addressed as a series of sequential management actions involving possibly large-scale manipulations, and the second can often be addressed on a site-specific basis as a unique preventive action. In the following sections, a number of reported management techniques of potential benefit to the black duck are discussed, and the pros and cons of each are described. Unfortunately, there are no ready means to compare the efficiency or efficacy of these management techniques because the

value of each can only be defined in terms of applicability to a particular management problem. Nonetheless, the intent of the presentation is to provide enough information for the manager to understand what each method is intended to accomplish and what difficulties might be encountered in its application. In another section, some suggestions of means to determine priorities—and thus obtain guidelines for specific selection of techniques—are provided.

Habitat Improvement

A host of management actions to improve the quality of upland and wetland habitat for waterfowl is available. Waterfowl habitat in the East has not, however, received the same attention as that in the midcontinent prairies, so some prescriptions must necessarily be generalized from the more specific guides to waterfowl management elsewhere.

Providing Pair Habitat

Although black ducks nest in low densities over extensive areas, concentrations of birds do occur in high quality habitat. Conflict among pairs and between pairs and unmated males adds to the female's energetic demands and can hinder nesting in extremely dense populations (Titman and Lowther 1975). Mendall (1949*a*) found that the number of black duck pairs using a wetland could not be increased until the habitat was broken into sections that could be used by individual pairs. Visual (or optical) isolation is entirely sufficient to separate pairs (Hughson 1971; Ringelman et al. 1982)—distances are largely immaterial, because the birds will not react to what they cannot see. Patterson (1976) has shown that pairs select habitat largely with respect to spatial considerations when populations are dense. It is presumed that other habitat factors play a larger role when encounters between conspecifics are rare (Kaminski and Prince 1981*a*,*b*, 1984; Murkin and Kadlec 1986).

There are several habitat manipulation techniques that are intended to provide isolated areas for pairs. These include construction of level ditches; dug and blasted potholes, pits, sumps, or dugouts; ditch plugs; and small dams for runoff ponds. When heavy machinery is used, construction of water control structures can be expensive (Schnick et al. 1982; Lokemoen 1984), but small hand-dug or blasted openings can be relatively inexpensive to construct. Although these areas will be used by pairs, in some soils the margins quickly slump and fill, and in coastal areas level ditches can break through to adjacent ditches and drain the marsh surface. Numerous structures of this sort in a small area look artificial and are unattractive. Careful disposal of spoil is required to prevent growth of undesirable plants and to prevent development of travelways for predators.

Another approach is to concentrate on the maintenance of small and isolated deciduous forested and deciduous scrub–shrub wetlands (terminology of Cowardin et al. 1979) that provide dense overhead and lateral cover. Purchase of these wetlands is not advised because they are an ephemeral type resulting from new floodings (Ringelman et al. 1982), but intensive management of beaver populations (discussed below) will accomplish the desired effect.

In coastal marshes, maintenance of small pools (pannes or *Ruppia* pools) in the upper marsh provides excellent pair habitat (Reed 1970). This requires that saltmarsh mosquito (*Aedes solicitans, Aedes cantator, Aedes* spp., *Anopheles* spp., *Culex* spp.; Daiber 1987) control practices that drain these pools be limited, a possible point of conflict with nearby communities.

For other waterfowl species in different habitats, the provision of loafing rafts or other structures has been suggested. No one studying the black duck has suggested that loafing spots are in short supply in pair habitat, so this is not a technique to be used.

Pairs will select habitat on the basis of food availability (Joyner 1980) as well as the isolation factors previously addressed. Therefore, the considerations for supplying high quality invertebrate foods noted for broods (discussed below) also apply to pairs in spring.

Monitoring of response to either development

or maintenance of pair habitat can be time consuming: Renouf (1970) continued to detect additional pairs through a sixth consecutive survey; Dzubin (1969) suggested four or five pair counts in spring in the prairies; Whitman (1987) found that two pair surveys were not enough for small wetlands in New Brunswick. Nonetheless, pair counts are less time consuming than brood counts, and can often be related to subsequent production if weather and phenology are taken into account (Reed 1975; Kirby 1980; Longcore and Ringelman 1980; Erskine 1987*a,e*).

Providing Nesting Cover

Because black ducks will nest in a diversity of sites, the best that can be advised is to discover the sites in use on an area and then to protect and augment those sites. Structural aspects seem important. Gavutis (1967) found that black ducks preferred vegetation at least 38 cm–61 cm high, and Coulter and Miller (1968) found nests on or near boundaries between vegetation types.

Birds will use the best cover available when they arrive in spring—often dead vegetation from the previous year. Later in the season, they will use new growth. It is therefore important that residual vegetation be present and that rank and dense low-growing bushes, shrubs, and trees be encouraged. In New England, Coulter and Miller (1968) suggested encouraging low growing conifers, vines, and shrubs. In the St. Lawrence, Reed (1964, 1968, 1970, 1973*b*) found that grass was a preferred nesting cover and suggested (Reed 1973*b*) that sweetgale waxmyrtle (*Myrica gale*), leatherleaf (*Chamaedaphne calyculata*), and spiraea shrubs (*Spiraea* spp.), as well as bluejoint reedgrass (*Calamagrostis canadensis*), white spruce (*Picea glauca*), and balsam fir (*Abies balsamea*), be encouraged as nesting cover. Suggestions that nesting meadows and grasslands be developed in the East seem implied in some management treatises, but their value to black ducks is doubtful. In any case, establishment of nesting grasslands in the East for ducks is usually only marginally successful, because heavy snows crush the residual vegetation, making the areas unattractive to birds in spring even though they may be used for later renests. Useful equivalents to the tall dense nesting cover suggested for the prairies (Duebbert et al. 1981) have yet to be developed. An alternative management technique for open fields is to spot brush, boulders, shrubs, and other snow-resistant structures randomly in the area to provide a break in habitat and cover for nests. In general, open fields are more attractive to species other than black ducks and often permit large populations of mallards to nest in what would otherwise be black duck habitat. This should be avoided (see section on competition).

In Maine, nests have been found on high spots such as boulders but also beneath slash piles at the base of trees and in thick stands of blackberry (*Rubus* spp.) canes (J.R. Longcore, personal communication). This suggests that "clean" forestry operations and burning of logging debris should be avoided. Stotts and Davis (1960) similarly suggested that the forested edges of wetlands in Chesapeake Bay be grazed lightly or not at all, and that land clearing and removal of debris be minimized.

On forested upland sites in general, cutover, amorphous habitat is best. Thus, development of forest openings for American woodcock (*Scolopax minor*) at the Moosehorn National Wildlife Refuge, eastern Maine, has also provided habitat for nesting black ducks.

In coastal marshes, many nests will be lost to tides. Thus Van Huizen (1932) suggested early spring burning of low marsh areas that would otherwise flood as a means to force birds to move elsewhere. In general, hummocks in the coastal marsh are preferred, just as they are in inland marsh areas. Early nests will be beneath marsh elder bushes (*Iva frutescens*) and in marshhay cordgrass or on dikes. These have a greater chance of success than later nests in tall smooth cordgrass which will be flooded (L.E. Widjeskog, personal communication). Little can be done to manage extensive tracts of coastal marsh for nesting birds except to use fire to maintain plant vigor (Kirby et al. 1988) and to refrain from dewatering the upper portions of the marsh. Birds nesting on dikes, however, can benefit if dikes are cut off from the mainland to prevent travel on them by predators. Perches used by American and fish crows (*Corvus*

brachyrhynchos and *C. ossifragus*) and raptors such as great horned owls (*Bubo virginianus*) may have to be removed to decrease predation in this linear habitat. If predation cannot be controlled, dikes should be mowed to make them unattractive to ducks.

Control of water levels is listed by many investigators as the key to prevention of early nest loss (Wright 1948, 1954; Stotts and Davis 1960; Payne 1984). Attempts to augment nesting habitat quality should therefore take into account probability of flooding, and impounded waters should be held at fixed levels until nesting is complete.

Artificial nests. In general, there are few indications that nest sites are limiting except in those areas with human development adjacent to the water or where there is no habitat of any sort for ducks—such as areas subject to spring plowing or already heavily developed with urban-suburban housing and recreation facilities. Stotts and Davis (1960), Coulter and Miller (1968), and Reed (1970) all indicated that black ducks preferred ground nesting. It seems that consistent use of tree and other elevated nest sites can be directly attributed to the low rate of success of nests on the ground in floodplains. Nonetheless, substantial effort has gone into attempts to develop populations that would nest in relatively predator-proof elevated cylinders. All of these attempts have failed, because the tradition could not be developed by imprinting the young on the structure (Bandy 1965; McGilvrey 1971; Lesser et al. 1974; Heusmann et al. 1979). At times, individual black ducks will use these elevated nests, and other sorts of elevated structures have been used. Cummings (1960) developed a wire basket for use in stumps that was used by black ducks and mallards in New York (Cowardin et al. 1967), but predation was high in the exposed sites and mallards used them more than black ducks (Foley 1968). Stotts (1958) found black ducks using offshore duck blinds for nest sites when other habitat was not available and suggested best management practices for constructing these blinds to develop the overhead and lateral cover desired by black ducks.

In studies of nest baskets in prairie habitat, high nest success rates have been documented for mallards (Bishop and Barratt 1970; Doty and Lee 1974), but two studies have demonstrated declining occupancy rate of these structures with time, despite high success rates (Bishop et al. 1978; Sargeant and Arnold 1984). Since this is the opposite of what would be expected if successful hens and young females from successful nests returned to use nest baskets in succeeding years, factors other than decreased likelihood of predation seem to be in effect in nest basket programs. Lack of maintenance of the structures may be one cause of declining use, but other factors are unknown. Therefore, although massive application of nest baskets in prairie habitats has been demonstrated to be a useful management tool for mallards in simulation studies (Cowardin et al. 1988), data available at present do not suggest similar results would be forthcoming for black ducks.

Other artificial nest sites for black ducks that have met with success are poultry wire rolls covered with hay (Coulter and Miller 1968) and floating northern white-cedar (eastern arborvitae, *Thuja occidentalis*) log rafts (Young 1968). Stotts and Davis (1960) proposed constructing brush piles specifically as nesting sites, and Brenner and Mondok (1979) provided a design for a small nesting raft.

Coulter and Mendall (1968) suggested that artificial nest structures should (1) require minimum maintenance, (2) not attract predators, and (3) be aesthetically harmonious with the environment. They concluded that such structures were unlikely to significantly increase total production. Their best use may be in areas of intensive management where nest success is otherwise very low.

Island construction. Stotts and Davis (1960) suggested constructing islands with dredge spoil, and Coulter and Mendall (1960) and Reed (1964, 1970) proposed specific management practices for island-nesting black ducks. Generally, islands should be maintained with the same nesting cover the birds prefer in surrounding areas. Where predators cannot be controlled, or where there is too much human disturbance, Coulter and Miller (1968) suggested clearing the understory and removing nesting cover to prevent nesting.

General criteria for island construction as developed for prairie wetlands (Hammond and Mann 1956; Jones 1975; Johnson et al. 1978; Duebbert et al. 1983) probably apply to the Northeast as well. It is best to consider island development during impoundment construction so heavy equipment can work on a dry site. Other types of islands include soil and rocks dumped on the ice during winter, and large hay bales placed directly in the wetland. Neither has been evaluated for black ducks. Island construction is very expensive (Lokemoen 1984), and as emphasized by Mendall (1949a) and Coulter and Miller (1968), there is no guarantee that black ducks will use an island, especially if other nesting habitat is nearby.

Three major considerations apply to management of islands: They must remain predator free; they must be free of human disturbance; and colonies of other birds detrimental to the ducks must not be allowed to develop. Waterfowl are attracted to larid colonies, and in many situations prefer to nest among breeding colonies of terns (Sterninae) and gulls (Larinae) (Vermeer 1968; Reed 1973; Young and Titman 1986). The relation of black ducks to larids on islands depends on whether gulls that are present are predators of ducklings or eggs. The limited data available suggest that predation by gulls on black ducks is unimportant to overall local population dynamics. Nonetheless, adult gulls can be substantial predators on young waterfowl (St. Lawrence; Reed 1968) if cover is limited. It appears that waterfowl nest and egg survival is increased in larid colonies because the larids exclude other egg-eating birds. However, survival of ducklings can approach zero as the number of nesting gulls that prey on ducklings nears 500 pairs (Dwernychuk and Boag 1972). Because almost total waterfowl reproductive failure as a result of gull predation has been recorded (Vermeer 1968), care should be exercised in permitting bare nest sites to develop on islands that might attract larger gulls.

Providing Brood Habitat

Hughson (1971) provided three suggestions for management of brood habitat: (1) establish stands of known spring foods (Mendall 1949*b*; Coulter 1955), (2) ensure flooding to a depth of 5 cm–61 cm, and (3) ensure visual isolation between stands of food. Erskine (1987*e*) concluded that brood survival in any area is likely to be influenced by available food and Ringelman and Longcore (1982*a*) identified brood requirements for horizontal and overhead vegetation for concealment from predators and shelter from severe weather. These assessments provide points of departure for consideration of management of brood habitat.

Foods. Mendall (1949*a*) believed that food was not limiting to black duck recruitment, but because the black duck has preferences, some gain could be obtained by planting burreeds (*Sparganium* spp.), bulrushes (*Scirpus* spp.), pondweeds (*Potamogeton* spp.), smartweeds (*Polygonum* spp.), annual wildrice (*Zizania aquatica*), common pickerelweed (*Pontederia cordata*), and Schreber watershield (*Brasenia schreberi*). Wildrice, considered exotic by some, has received good use by ducks in the boreal forest (Peden 1977). The most important need was, Mendall (1949*a*) believed, to control water level so the preferred foods would be available. Further advice on food plantings may be found in Pirnie (1935), Addy and McNamara (1948), and Fredrickson and Taylor (1982).

Although early management concentrated on planting foods for the direct benefit of providing roots, tubers, and seeds, further emphasis has been on supplying appropriate vegetation for invertebrates (Mendall 1973). Natural seed banks seem adequate to develop stands of vegetation in most marshes (van der Valk and Davis 1978; Smith and Kadlec 1983, 1985) and planting has become restricted to special cases of intensive management of emergents, such as in management of moist soil impoundments (Fredrickson and Taylor 1982). Even here, the emphasis is on providing substrate for invertebrates.

Because the association of invertebrates with aquatic vegetation is clear (Krull 1970; Whitman 1976; Murkin and Batt 1987), and because herbaceous vegetation supports a greater biomass of aquatic invertebrates than any other plant life form (Reinecke 1977), habitat management should seek to maximize patches of this vegetation for brood use. Moyle (1945, 1949, 1956) and Patterson (1976) have identified correlations between water quality

and vegetation abundance that can provide guides to vegetation production capability. More productive waters are worthy of special attention. Reid (1985) provides a discussion of the relation between water chemistry, flooding cycle, and invertebrate production.

Food quality and quantity do not seem to be limiting for either adult female (Reinecke and Owen 1980) or young (Reinecke 1977) black ducks in inland Maine or similarly productive freshwater wetlands. Likewise, they are not limiting in coastal marshes (Reed 1968, 1970), but may be limiting in areas with older impounded waters or in areas with brownwater streams of low pH (Erskine 1987*e*). Beaver can increase the productivity of poor quality brownwater streams through their wood cutting and dam building activities (Naiman and Melillo 1984) and should be protected in such areas. Fish sometimes compete with ducklings for food. These aspects are further discussed in the following sections.

Cover. Patterson's (1976) Ontario data clearly showed that broods select habitat on the basis of food quantity and quality and the availability of escape cover. For dabbling ducks, escape cover can be emergent vegetation or thick woody vegetation that provides overhead and horizontal visual obstruction. Early successional stages of freshwater aquatic vegetation and newly flooded live woody vegetation should be protected and enhanced for black duck broods as should riparian vegetation along streambanks and lakeshores. In coastal marshes, small ponds on the marsh surface should be maintained or developed; tidal flushing of all ditches and creeks should remain unobstructed to permit brood movement in the marsh; and marsh burning should not be conducted over large tracts (Lynch 1941; Hoffpauir 1961; Chabreck 1976; Hackney and de la Cruz 1981). Grazing and trampling of the upper reaches of the salt marsh can be harmful to broods, as can heavy human traffic involved with fishing, crabbing, and other recreation that removes creekbank vegetation. New ditching, especially that for mosquito control, often develops steep-walled banks that will not permit duckling egress at low tide. Decreased slope of ditch walls at irregular intervals can be one solution. Heavy boat traffic in both salt and fresh marshes and waterways destroys vegetation and causes erosion of banks, reducing brood use (Benson 1968). This should be avoided, as should manipulations of emergent habitat to remove broad strips (for boat access, etc.) that in effect create large bare areas of shore that will block brood movement for lack of cover.

Monitoring brood response to habitat manipulation is difficult and time consuming, because black duck broods are among the most wary of ducks. Bartlett (1987) and Erskine (1987*c*) found it necessary to make four or five and three counts, respectively, before confidence in trend data was obtained. An additional complication in assessment of brood response to habitat manipulation is the interaction between (1) nest, duckling, and brood survival; (2) renesting by some females; and (3) habitat choice by the female and brood. Data from Ile aux Pommes (Reed 1975) showed that renesting may compensate for nest loss in some years but not in others, and that the proportion of females that do not bring off broods varies from year to year. Thus, annual variations in the rate of production of newly hatched young are largely governed by nesting success rates and renesting persistency. Attempts to relate numbers of birds to specific habitat therefore must incorporate not only response to habitat per se but also the success of the reproductive effort that year. Van Horne's (1983) warning—that positive correlation between animal density and habitat quality cannot be assumed without supporting demographic data—is especially pertinent, because high quality habitat cannot offset the population effects of early and total brood loss or nest loss not replaced by renesting.

Despite such difficulties, obtaining data on brood use of the management area is necessary to any scheme for monitoring brood response to habitat manipulation. Guides to brood counting methods (Gollop and Marshall 1954; Hammond 1970; Reed 1975; Kirby 1980; Longcore and Ringelman 1980; Rumble and Flake 1982) should be modified to meet local conditions or entirely new techniques derived to address wooded or shrub-covered inland wetlands and extensive tracts of salt marsh. Every effort should be made to quantify and compare brood use between habitats within the management area. This is the simplest means

of removing the confounding effects of annual changes in black duck productivity.

Studies of brood survival on managed areas would be excellent means to quantify the success of habitat manipulations, but brood survival studies are difficult to conduct. Only intensive visual observation of marked broods will give unequivocal results (Ball et al. 1975; Reed 1975; Ringelman and Longcore 1982*b*). Unsophisticated approaches that measure "apparent" brood survival, based on observed losses of young from unmarked broods, fail to account for total brood loss and brood movements, and give exaggerated estimates of productivity. Evaluation of the success of a management scheme should never be based on between-year comparisons of apparent brood survival.

Managing Impoundments and Other Wetlands

Weller (1978, 1981) made a strong plea for use of natural forces and processes in wetland management, because they are most likely to stimulate the wetland in the direction of natural results. These methods include water level manipulation; management of herbivores such as muskrats (*Ondatra zibethica*), beaver, and nutria (*Myocastor coypus*); and use of fire. Artificial methods include modification of the wetland basin, planting and cutting vegetation, use of herbicides, and construction of artificial nest platforms, islands, etc.

Vegetation goals. Avian populations are dramatically affected by the spatial distribution and interspersion of wetland vegetation and open water (Weller and Spatcher 1965; Weller and Fredrickson 1974). Waterfowl studies (Kaminski and Prince 1981*a,b*, 1984) have shown that the hemi-marsh (a 50:50 ratio of emergent vegetation to open water) should be the goal of vegetation management. At this stage, invertebrates are abundant and the most habitat is provided for pairs and broods. Drawdowns (see water level control section) and various other manipulations (such as rototilling the marsh bed, mowing on the ice, or burning emergents) can provide the interspersion desired. Linde (1985) provides specific suggestions for managing vegetation in impoundments through means other than water level control; Knighton (1985*a*) provides guidelines for vegetation management solely through water level control. Buech (1985) addresses the special problems involved with managing man-made and natural wetlands that also contain beaver.

Water level control. The need for periodic drawdown of man-made impoundments and other waters has been recognized since the early work of Kadlec (1962) and Harris and Marshall (1963). Drawdowns permit the natural propagation and growth of desired vegetation; retard plant succession; increase interspersion of cover and water; remedy damage to vegetation from ice action and continuous flooding; eradicate undesirable vegetation; reduce the effects of turbidity and low pH in some waters; release chemically bound nutrients; compact organic soils to provide a firm substrate for rooted aquatic plants; can act as pest insect control measures; and can reduce muskrat and common carp (*Cyprinus carpio*) populations. Periodic drawdowns are absolutely necessary to the continued productivity of freshwater impoundments (Linde 1969; Whitman 1976), and natural drawdowns through drought or failure of beaver dams help maintain productivity of basin wetlands. Three problems with drawdowns in the East are (1) the possible development of dense stands of undesirable purple loosestrife (*Lythrum salicaria*) if the area cannot be reflooded on schedule, (2) the possible development of disease potential in remaining anaerobic waters, and (3) the often difficult process of managing water levels if beaver are in the impounded drainage. A guide to addressing purple loosestrife problems is available (Thompson et al. 1987) and the National Wildlife Health Research Center, Madison, WI, can provide advice on best drawdown schedules for prevention of disease problems. Buech (1985) provides advice on both immediate and long-term beaver management methods in impoundments.

Drawdown schedules at various intervals accomplish different purposes, but in most cases, there should not be more than 4 or 5 yr between drawdowns (Whitman 1976). A summary of various studies and advice on selecting optimum drawdown times is in Schnick et al. (1982). Knighton (1985*a*) provides guidelines on obtaining optimum

interspersion of vegetation and means to estimate the management capabilities on a site through water level control. Partial drawdowns are preferred for brood waters because invertebrate populations are maintained. Bottom topography, soil characteristics, existing plant communities, current waterfowl use, productivity, and seasonal water supplies are all factors to consider when contemplating drawdown as a water management technique (Yoakum et al. 1980).

Impoundment construction. The mechanical and legal aspects of impoundment construction are fairly straightforward (U.S. Department of Agriculture, Soil Conservation Service 1975; Anderson 1985; Farmes 1985) and criteria have been identified to guide siting of impoundments (Linde 1969; Verry 1985). Neither of these aspects will be considered further here.

The important question for black duck management is: What is actually to be accomplished by impoundment construction? There is no doubt that an impoundment created in an upland site develops new water resources, but unless lack of habitat per se was already limiting the waterfowl population, there is no reason to believe that substantial increases in the total population will occur. Instead, the first result is the rearrangement of the birds to take advantage of the new and highly productive waters. Only if reproduction on the impoundment exceeds what would have otherwise occurred will there be population growth. It is important to remember that there is no significant reason to believe that waterfowl productivity will be higher, and reason to believe that it might be lower if nests are concentrated along with predators. Spectacular increases in waterfowl populations on new impoundments (Whitman 1973, 1976) have undoubtedly resulted from draining of the population from a wide area (Munro 1968). Although pleasing to the public and seemingly indicative of success, such increases in duck numbers are only changes in distribution. Many impoundments thus may not be accomplishing stated goals for black ducks even though other wildlife resources will benefit.

Even small impoundments are very expensive to construct (Lokemoen 1984) and some of the chemical and vegetative results of impounding water in a basin may be relatively irreversible (Thibodeau and Nickerson 1985). It is imperative to carefully weigh cost versus benefit before initiating impoundment schemes and to carefully integrate impoundment and natural wetlands management (Spencer 1963).

These cautions apply even more stringently to impoundments in the salt marsh. The area of natural salt marsh habitat is steadily shrinking because of human degradation and development of these lands. In addition, changes in sea level are continuing to drown the foreshore without the marsh being able to move inland because of fixed upper boundaries to marshes such as seawalls, roads, and dwellings (Redfield 1972; Committee on Impacts of Emerging Agricultural Trends on Fish and Wildlife Habitat et al. 1982; Nixon 1982; Tiner 1984). The Atlantic coast of New Jersey is a prime example of this phenomenon (Kaufman and Pilkey 1979; Pilkey and Evans 1981). Changing an open salt marsh to an enclosed system is therefore a drastic change in type that is justifiable only in the most extraordinary circumstances.

Although opinions of the value (and necessity) of detrital export from coastal marshes to the adjacent estuarine system have been revised since Teal's (1962) initial discussions (Nixon 1980; Teal 1986), there is little doubt that completely enclosed impoundments are detrimental to fish and wildlife resources (Zale et al. 1987). Studies of marsh productivity clearly show that impounded coastal waters are less productive than those open to tidal circulation (Mann 1973; Odum et al. 1983). A management scheme with great potential benefit is the restoration of impounded areas—such as salt hay (*Spartina patens*) farms—to tidal circulation (Ferrigno 1964; Ferrigno et al. 1987).

Substantial questions remain on the best management schemes for existing coastal impoundments (Odum et al. 1984; Hardin 1987; Whitman and Cole 1987), and much is yet to be learned of the exact effects of impoundments on coastal flora and fauna (Montague et al. 1987*a*,*b*). There are no data to show that overall production of black ducks has increased with the construction of salt marsh impoundments, although other bird species may benefit.

Burger et al. (1982) specifically suggested that natural salt marshes should be maintained because they are necessary habitats for some species, even though the diversity and avian biomass is less plentiful on natural than managed (impounded) marshes. Reed's (1973*b*) emphasis is well taken: Coastal marshes should be maintained in as near to pristine conditions as possible to obtain the maximum benefit for black ducks.

A final caution about impoundment construction is the fact that hunters become very efficient at removing all of the local waterfowl production on an impoundment during the hunting season. Thus, the expectation that a surplus of birds will develop, leave the impoundment, and populate surrounding areas remains unrealistic in most circumstances. Instead, the situation comes to resemble various "put and take" operations as are used for trout (*Salmo* spp.) and ring-necked pheasants (*Phasianus colchicus*), and the impoundment does little to increase populations other than on a local level (Erskine 1987*b*). It must be emphasized that there have been no studies of wide areas before and after impoundment construction to quantify overall changes in the population of black ducks, despite the common but misunderstood perception that there are "more" ducks because they are concentrated where they can be seen.

Beaver Management

H.E. Spencer, Jr. has been a tireless advocate of beaver management as a means to provide needed habitat for the black duck [Spencer 1957, 1980, 1986; comments in Barske (1968) and Atlantic Waterfowl Council et al. (1973)]. Nonetheless, a coherent strategy to optimize widespread beaver management for the benefit of black ducks has yet to be developed. Beaver flowages have been recognized for years as high quality waterfowl habitat (Pirnie 1935; Beard 1953, 1964; Knudson 1962; Jahn and Hunt 1964), and early studies confirmed their value to black ducks (Wright 1954; Hodgdon and Hunt 1955; Stanton 1965; Nevers 1968*a*,*b*). There is no doubt that beaver ponds are preferred habitat of the species throughout its range (Renouf 1970; Whitman 1987). Reasons for this seem to be that (1) new impoundments provide excellent cover in their flooded and still-living emergent vegetation, trees, and shrubs; (2) their invertebrate productivity is high because of the new flooding and the activities of the beaver in felling trees, adding debris to the flowage, bringing mud from the basin floor to the dam and lodge surface, and defecating in the water; (3) the natural drawdowns of the flowages increase the period of their value to ducks; and (4) as the beaver exhaust their food supply the flowage is abandoned and a new impoundment is built, renewing the cycle and the value to the birds (Beard 1953; Kirby 1973; Hepp and Hair 1977; Brown and Parsons 1979).

Management of beaver to benefit waterfowl includes:

- Maintaining populations at as high a level as possible without causing undue economic damage.
- Transplanting beaver into areas where impoundments are needed.
- Human maintenance of beaver dams temporarily abandoned by the beaver but in areas where water and wetlands are lacking in quantity or quality.
- Use of water control devices to maintain flowages at desired levels.
- Judicious use of trapping programs to maintain populations at desired levels.
- Shoreline manipulation to encourage or discourage beaver in forested areas.

Muskrat Management

Drought will eliminate muskrats from a marsh (Errington 1963), but they invariably return with higher water. These rodents can quickly reproduce and in a single season can literally strip a marsh of vegetation. Marshes without capability of water level control are particularly vulnerable to explosive population increases. Before this occurs, a trapping program can be used to keep muskrats at a level compatible with maintaining a hemi-marsh. If drawdowns are possible, they alone can be used to regulate the muskrat population. On larger marshes, constant assessment of the muskrat population is necessary to prevent destruction of all

vegetation. A continuous and vigorous muskrat control program is probably the best approach for a duck marsh (Weller 1981).

Mosquito Control

Some detrimental aspects of initial "grid" or "parallel" ditching to waterfowl, shore and marsh birds, and invertebrates were identified early (Urner 1935; Bradbury 1938; Cottam et al. 1938; Bourn and Cottam 1950; Cottam and Bourn 1952), but the exact effects of this means of mosquito control are difficult to describe (Daiber 1974). Ditching does drain the surface of the marsh and removes the small depressions and pools containing vegetation and invertebrates important to black duck survival.

More recent methods of mosquito control include "open marsh water management" (OMWM), which does not develop grid ditching. This procedure uses selected ditching of major mosquito depressions, but shallow depressions are filled, and surface water is collected in ponds large enough to support fish which feed on mosquito larvae (Ferrigno and Jobbins 1968; Ferrigno 1970, 1984; Ferrigno et al. 1976). Following decades of experimentation with both chemicals and manipulation of water in coastal marshes, the combination of physical and biological controls incorporated in OMWM has come to be considered the most economical and efficient solution to salt marsh mosquito problems yet devised (Daiber 1987).

The dependence of salt marsh birds on small pools on the marsh surface has been well established (Reed 1970; Clarke et al. 1984). Ditching of surface ponds reduces invertebrate species richness and diversity (Barnby et al. 1985) and thus is capable of reducing the value of coastal marshes to waterfowl and other birds (Wilson et al. 1987). Modifications of the OMWM technique (including maintenance of small pools on the marsh surface, less disturbance of existing drainage systems, and return of grid-ditched marshes to natural conditions) seem preferable for simultaneously managing mosquito problems and providing benefits for waterfowl. Current programs in Delaware are taking this approach and returning water to the surface of previously grid-ditched marshes (W.R. Whitman, personal communication; Mahaffy 1987; Meredith and Saveikis 1987).

Hruby et al. (1985) and Brush et al. (1986) described results of modification of OMWM for New England conditions and Meredith et al. (1985) describe modifications for use of OMWM in Delaware. These are without doubt less damaging to the ecological functions of the marsh. Nonetheless, despite several studies to evaluate the biological effects of OMWM (Ferrigno 1970; Burger et al. 1982; Resh and Balling 1983; Clarke et al. 1984; Brush et al. 1986; Shisler and Ferrigno 1987), it has yet to be conclusively proven that black ducks are benefited by the process. Current research is attempting evaluation of OMWM in the mid-Atlantic States including study sites on Bombay Hook National Wildlife Refuge (W.R. Whitman, R.M. Erwin, and M.A. Howe, personal communication) and elsewhere (Shisler and Ferrigno 1987; Wilson et al. 1987).

Chemical control of mosquitoes on the salt marsh and elsewhere—including spraying of diesel fuel or kerosene on open ponds—is detrimental to black ducks because it removes important invertebrate food sources. Complications resulting from dependence on chemical control measures for mosquitoes were outlined by Daiber (1987).

Management of Surrounding Lands

It has long been recognized that lands adjacent to areas managed for waterfowl play a major role in the entire management scheme. Gabrielson (1947) entered an early plea to encourage owners of private wetlands to manage them for the benefit of the black duck. Reed (1973*b*) suggested development of programs to make landowners aware of duck nesting requirements in the St. Lawrence, as did Coulter and Miller (1968) for islands in northern New England. At a more political level, Erskine (1987*b*) suggested that one of the greatest benefits to waterfowl in the Atlantic Provinces would be to remove subsidies for maintenance of marginal agricultural lands. Informing adjacent and other landowners of the habitat requirements of the black duck—especially its need for seclusion and high quality pair, nesting, and brood habitat—can reap benefits for the population over a large

area if land use practices are modified. Public education is a necessity in any program designed to increase black duck numbers in the United States.

Reduction of Mortality and Competition

Mortality

Mortality factors for waterfowl are difficult to quantify, mainly because dead birds are hard to find except during large-scale die-offs from disease. Activity of scavengers, vegetation density, carcass visibility, the mortality factors involved, and severe weather combine to cause significant but unknown underestimation by field search methods of nonhunting mortality (Humburg et al. 1983). Two biotelemetry studies of breeding black ducks provide insight upon the scale of mortality involved for adult females (Ringelman and Longcore 1983) and ducklings (Ringelman and Longcore 1982*b*), but substantial additional data are needed before range-wide generalizations are possible. Changes in bird numbers for any large or small area within and between years can be identified only with substantial effort, and changes in migratory bird numbers cannot always be attributed to local factors. Nonetheless, in certain circumstances, the impact of one or several mortality factors can be identified, and management steps can be taken to alleviate their effects upon the locally-breeding duck population.

Predation. Known predators of the black duck (from the summary by McGilvrey 1968) include raccoons (*Procyon lotor*), crows, gulls (*Larus* spp.), red foxes (*Vulpes vulpes*), Virginia opossums (*Didelphis virginiana*), black rat snakes (*Elaphe obsoleta*), fox snakes (*Elaphe vulpina*), Norway rats (*Rattus norvegicus*), skunks (*Mephitis mephitis*), and weasels (*Mustela* spp.). At various times, snapping turtles (*Chelydra serpentina*), bass (*Micropterus* spp.), chain pickerel (*Esox niger*), American eels (*Anguilla rostrata*), bowfin (*Amia calva*), trout (*Salmo* spp.), and northern pike (*Esox lucius*) may take ducklings, and probably all other carnivorous or omnivorous marsh-dwelling organisms—including raptors and domestic or feral animals—will take ducklings opportunistically. The raccoon is probably the most important nest predator (Wright 1954; Stotts and Davis 1960; Gavutis 1967) and the crow the most prevalent egg predator (Andrews 1952; Stotts and Davis 1960). Snapping turtles (Coulter 1957) and mink (*Mustela vison*) may be the most effective predators of young.

In high-quality nesting and brood-rearing habitat, predation is not a problem for the black duck. On small areas, or those under intensive management, however, local control of some predators may be justified (Mendall 1973). Reduction of predation may be accomplished by direct removal of the predators, exclusion of predators, habitat manipulation, or a combination of techniques. Sargeant and Arnold (1984) provide a review of these techniques as they have been applied on Waterfowl Production Areas in the prairies. There are few proven efficient and cost effective methods available to solve the problem, and presently no research is under way to address this issue with regard to the black duck in the eastern United States.

Predator control methods reported in the literature for benefit of black ducks cannot be generalized as each was designed for a site-specific problem. In addition, evaluations of response of the waterfowl population are only rarely made, and most predator management programs for the benefit of the black duck have not been conducted long enough for unequivocal results to be obtained. Gavutis (1967) did find that nest success improved at Brigantine National Wildlife Refuge after seven raccoons were removed. This type of site-specific predator management has been reinitiated on several northeastern Refuges and waterfowl management areas with positive results.

It is clear that predators should be removed from islands and their numbers reduced in closed impoundments if duck nesting is to be successful, but no other generalities are possible. Because of the dispersed nature of most black duck nests, it seems best to concentrate on developing quality habitat instead of concentrating on predator control. If predator control is contemplated, it must be understood that once begun, it becomes an annual effort if duck production remains the focus.

Disease and parasites. Data on the effects of

disease on free-living black duck populations are meager, but disease is considered directly or indirectly responsible for the largest proportion of nonhunting waterfowl deaths (Bellrose 1978). Unique occurrences of black duck deaths from disease have been noted, such as botulism in New Jersey (Reilly and Boroff 1967) and "red tide" caused by dinoflagellate toxins (Sasner et al. 1974). *Leucocytozoon simondi*, a blood parasite obtained from black fly (primarily *Simulium ruggelsi* and *S. anatinum*) bites, has long been known to infect black ducks (Nelson and Gashwiler 1941; O'Meara 1956). Some ducklings die from this parasitism in laboratory situations, and it is suspected of causing substantial deaths of ducklings in the wild (Bellrose 1978), but the overall consequences on black duck populations are unknown. Whitman (1976) suggested, however, that black duck numbers could be reduced throughout their range because of the effects of this lethal hematozoan and the high rate of infection in black ducks (Bennett 1972; Bennett et al. 1974,1975). Anthropogenic changes in lotic waters of the Northeast have made the black fly vectors of this disease more prevalent and have extended the season of their occurrence (J.R. Longcore, personal communication), suggesting the need for monitoring of the impact of this parasite on black duck populations.

Black ducks have the usual internal parasite burdens (McLaughlin and Burtt 1973, 1979) and skin parasites (Clark and Stotts 1960), but the population consequences of these also are unknown. Bennett et al. (1973) and Whitman (1976) provide discussion of black duck parasitism and suggestions regarding monitoring of disease and parasite vector incidence. Wobeser (1981) and Friend (1987) provide thorough reviews of current knowledge of avian disease identification and management. The National Wildlife Health Research Center, Madison, WI, can provide assistance with specific disease issues.

Contaminants. Longcore and Stendell (1982) showed that black duck reproductive success was probably impaired by DDE in the 1960's and earlier. Although residues of DDE in the environment are now much lower (Prouty and Bunck 1986), no data are available on the effects of other persistent contaminants (pesticides, herbicides, metals, etc.) on free-living black duck populations. The effects of broadcast spraying for spruce budworm (*Choristoneura fumiferana*) control in Canada (Webb 1959) has not been thoroughly evaluated with regard to black ducks. Recent studies of the effects of insecticides on young black ducks showed reduced growth rates as a result of reduction in invertebrate foods (Hunter et al. 1984; Brown and Hunter 1984/85). This suggests that the consequences may be substantial and worthy of further research.

Acidification of wetlands. The effects of industrial and urban emissions of sulfates and nitrous oxides on the biota of aquatic ecosystems have been well documented and are a subject of considerable international concern in North America. Loss of fish, altered prey–predator relations, and loss of acid-sensitive invertebrates in aquatic systems often result in substantial changes in avian trophic relationships following acidification (Mayer et al. 1984; McNicol et al. 1987). Negative correlations between wetland acidity and avian distribution (DesGranges and Darveau 1985) and breeding success (Blancher and McAuley 1987) have been documented, and the results of acidification seem capable of exacerbating the risk to species with low or declining populations, such as the black duck (DesGranges and Hunter 1987; Hansen 1987; Longcore et al. 1987). The major documented effect of acidification on black ducks is loss of food resources for ducklings and thus reduced growth and impaired physiological condition of young (Rattner et al. 1987). The net effects of wetland acidification are difficult to predict because interaction with fish fauna complicates assessment (Desgranges and Hunter 1987) and acid conditions are reversible (Longcore et al. 1987). Black duck managers should be aware of both the short- and long-term consequences of wetland acidification, but currently, suggestions for site-specific management response to acidification have not been developed for breeding habitats of waterfowl in the United States.

Lead poisoning. The U.S. Fish and Wildlife Service's Lead Monitoring Program has identified the Atlantic Flyway as that with the highest percentage of ducks with elevated lead levels. Black ducks have historically had a

higher prevalence of ingested lead shot than mallards (Bellrose 1959; U.S. Fish and Wildlife Service 1986). This higher prevalence is supported by surveys of lead in wing bones of eastern waterfowl (Stendell et al. 1979). The diet of black ducks seems to protect them from some of the negative effects of lead ingestion (Chasko et al. 1984). Nonetheless, although not yet entirely quantified, the sublethal effects of lead poisoning on growth, susceptibility to predation and disease, and subsequent productivity of waterfowl may be substantial. Because unequivocal identification of death as resulting from lead ingestion at a particular site is extremely difficult, it seems best to incorporate reduction of potential for lead poisoning in all habitat management schemes on the breeding grounds. Current U.S. Fish and Wildlife Service research is attempting further quantification of the effects of lead poisoning on black ducks (S.D. Haseltine, personal communication). The planned nationwide change to steel shot should make this a less important factor with time.

Accidents. Stout and Cornwell (1976) reported statistics on accidents in waterfowl. There is no reason to believe that black ducks are more prone to accidents than other species.

Hunting. Greatly increased samples of banded birds and increases in the sophistication of means to analyze banding data have permitted several comprehensive analyses of black duck populations, including the effect of hunting on population dynamics of the species, but with equivocal results. Band recovery data show that there is a substantial differential in mortality rates between young and adult black ducks, with the greatest portion of the differential being the result of greater vulnerability to hunting and nonhunting mortality factors among young birds (Krementz et al. 1987,1988). The absence of strongly time-dependent survival rates among black ducks suggests that variation in hunting mortality is compensated for by other mortality factors, but results are not definitive (Krementz et al. 1987). Further, black duck band recovery data have also shown that recovery rates of sympatric black ducks and mallards are similar, but tests for differences in annual survival rates between black ducks and eastern mallards banded in the same areas are equivocal (Nichols et al. 1987). This leads to the conclusion that differences in population status between black ducks and mallards in the East do not seem to result from differences in mortality rate, but instead relate to differences in reproductive rates or differences in migration in and out of populations.

None of the results of analysis of banding data provide concrete suggestions regarding the appropriate mix of habitat and hunting program management schemes that would be best for a given population of birds, especially those on and near breeding grounds. But since there is likewise no definitive conclusion yet possible regarding the effects of hunting on black ducks as a species throughout their range, Krementz et al.'s (1987,1988) conclusions warrant attention: (1) the entire subject is in need of substantially more study, and (2) conservative approaches to managing hunting of black ducks may be warranted.

As to the effect of hunting on local populations, it is clear that hunting mortality is often sufficient to remove a major portion of the young-of-the-year and often the adult females as well, if hunters and ducks are concentrated on small areas at the beginning of the waterfowl season (Jahn and Hunt 1964; Kirby et al. 1976, 1983; Cowardin and Johnson 1979). Reed and Boyd (1974) and Blandin (1982) argued that some black duck populations cannot sustain current harvest levels, but the reader should refer to Boyd and Hyslop (1985, 1986) and Conroy and Krementz (1986) for further discussion. It appears that hunting mortality may be greater than the species can accommodate at certain times and places. Such mortality is incompatible with the objective of increasing the population.

Although beyond the scope of this report, it is clear that innovative approaches to managing hunting are needed on some sites if the local black duck population is to be increased. Much more needs to be learned of the timing, extent, and consequence of hunting mortality to black ducks (Rogers and Patterson 1984; Erskine 1987*b*; Krementz et al. 1987,1988), and the relation between hunting and nonhunting mortality.

Trapping. Spring trapping kills many black

ducks (Gashwiler 1949) and should not be permitted in areas where increases in black ducks are desired. Potential conflict between furbearer management and waterfowl objectives should be evaluated any time trapping programs are considered within the range of the black duck. It is important to note that use of Conibear traps instead of standard leghold traps in muskrat, beaver, and mink sets does not guarantee that waterfowl will not be caught. A hatching-year female black duck marked with a radio transmitter in northern New England was found in a Conibear trap in New Brunswick (J.R. Longcore, personal communication).

Competition

Competition occurs when the use of a resource by an individual reduces the availability of that resource to another individual, whether of the same species or not. (Resources include food, space, water, etc.) Competition is detrimental to both individuals and at one extreme leads to the exclusion of one party (or population or species) over time. To the extent such phenomena affect black duck population dynamics and distribution, competition is of consequence to waterfowl managers.

Fish. There are data to suggest that fish may be, at times, competitors with ducks for invertebrate foods (Eriksson 1979; Pehrsson and Nystrom 1988) and that acidification of waters exacerbates the problem for ducklings if the area is already poor brood-rearing habitat (DesGranges and Rodrigue 1986; Hunter et al. 1986). The conclusion is that some poor-quality waters contain too few epibenthic invertebrates for fish and ducks to coexist, and that changes can be expected with increasing deposition of industrial pollutants. There is no suggestion that competition with fish for invertebrates is of consequence on more productive waters, but the threshold of the effect is unknown (DesGranges and Hunter 1987).

Mallard. There have been substantial changes in both numbers and distribution of black ducks and mallards in eastern North America since at least the early 1900's. The mallard has moved far to the east and the black duck has moved slightly west around the Great Lakes. The black duck has remained in forested areas, apparently unable to compete well in grassland ecosystems, but the mallard has left the prairies and entered what was originally only black duck habitat. The propagation and release of mallards in the East has confounded analysis to a certain extent, but the results are unequivocal: Mallards now breed in substantial numbers—in suburban and farmland habitat as well as areas largely unaffected by man—throughout the East with the exception of extreme eastern and boreal Canada (Johnsgard 1961, 1967; Heusmann 1974; Johnsgard and DiSilvestro 1976; Spencer 1980, 1981, 1986; Rogers and Patterson 1984).

Changing agricultural and other land use practices (including large-scale forestry and recreational development in remote areas) have benefited the mallard and not the black duck, as trees have been cleared, wetlands reduced in number, and suburban development has replaced unbroken woodlands. The mallard is more tolerant of disturbance by man and can reproduce well in areas in which black ducks will not be found. The result has been that where mallards now exist in quantity, there are fewer black ducks. The exact mechanisms of competition, if any, are unknown, but marked declines in black duck numbers have been noted in Ontario concomitant with this increase in mallard numbers (Collins 1974; Dennis 1974*a,b*; Dennis and North 1984*a,b*). Hunter-kill data confirm this relationship on the Canadian breeding grounds; Ankney et al. (1987) provide an explicit example for Ontario and Quebec.

Accompanying the relative increase of the mallard has been an increase in hybridization between the black duck and mallard, especially in wintering areas where sex and species ratios are often substantially unbalanced (Goodwin 1956; Brodsky and Weatherhead 1984). The black duck, with the smaller gene pool, has been the loser in this interaction. Current estimates of the proportion of hybrids in the fall waterfowl harvest in the United States [hybrids/(hybrids + black ducks) = 0.114; R.E. Kirby, P. Dupuis, and G.L. Hensler, unpublished data] substantially exceed earlier estimates and indicate the magnitude of the interaction taking place. The ultimate consequences of this hybridization do not

appear advantageous for the black duck. Therefore, there have been calls for cessation of release of mallards in the East and the initiation of studies to evaluate interactions of the two species on the breeding grounds (Spencer 1980; Stotts 1987).

From the management perspective, it seems clear that the black duck is not benefited by development that provides habitat for mallards. This includes commercial, recreational, and residential shoreline development; marsh destruction of all types; development of open marshes in boreal habitat; and release and maintenance of domestic and hand-reared birds. The wintering of large flocks of mallards in park environments also has been detrimental to black ducks (Heusmann and Burrell 1984; Heusmann 1987). Management to benefit the black duck and not the mallard must therefore concentrate on stopping the release of mallards into black duck habitat; cessation of habitat change near prime black duck breeding habitat that would attract mallards (such as open fields); reduction of captive waterfowl and domestic flocks that attract mallards; and perhaps the removal of mallards from areas where black ducks are a major concern. This means that all habitat alteration projects should be evaluated regarding their attractiveness to mallards, and that the black duck's preference for seclusion in a dispersed population on scattered freshwater wetlands and in salt marshes should be recognized in every management action.

Humans. Beard (1953), Wright (1954), Mendall (1958, 1973), Coulter and Mendall (1968), and almost all others who have studied the black duck mention disturbance by humans as a major factor in determining probability of a successful nesting attempt. Disturbance causes desertion of nests, mixing of broods, loss of ducklings, and increases opportunities for predation of eggs and young. Since early nests have larger clutches, factors increasing renesting directly affect productivity. Disturbance can also be detrimental to habitat if land clearing, brush cutting, or other activities occur. Sometimes disturbance is overt, with eggs and nests being vandalized or eggs illegally removed by aviculturists; more often, the disturbance is not known to the visitors to nesting areas. Indeed, many may not even realize that ducks nest in the vicinity (Coulter and Mendall 1968). Public education is the key to reducing mortality from this factor.

Implementing Management

Changes in numbers and distribution of a waterfowl population depend on the extent to which the habitat provides the life requisites of the species. Because of the complexities of natural communities, however, it is only in unusual cases that limiting factors can be identified and particular efforts made to resolve shortcomings in only a single area. Instead, waterfowl management concentrates on supplying the sum of necessities, usually simplified as "food, water, and cover." To this must also be added (1) a spatial dimension, because interspersion of habitat attributes affects their suitability; (2) a time dimension, because resources must be available at the appropriate times in the annual cycle; and (3) a human dimension, because the actions of man can have long-lasting and far-reaching effects on the environment.

It is a common fiction that with each additional management effort the value of an area being managed increases—that is, if a little is good, then more must be better. Management treatments cannot be considered to affect waterfowl populations in a simple additive manner. What counts is progress toward scientifically derived objectives, not accumulation of manipulation of the environment. Success in a program, particularly regarding waterfowl, does not necessarily mean the greatest number of birds on a particular site. More important is the dynamics of the population and the direction of change in numbers. Management solely to concentrate birds invariably leads to shortcomings in nesting and brood-rearing habitat, and the population benefits not at all from the overmanagement.

The life requisites (and thus management needs) of many wildlife species are incompatible with maximizing similar benefits for other species. Therefore, if a management goal is maintenance of species diversity, protection of endangered species, providing public recreation,

etc., it may be impossible to simultaneously maximize the value of an area to waterfowl. In most circumstances, priorities will be clear, because they are mandated by extrinsic requirements of the agency. Where priorities are not clear, the manager should explore the ultimate consequences of long-term management solely for the benefit of waterfowl before embarking on an ambitious program.

Unfortunately, wetland management as a whole is poorly founded in theory and as a predictive science (Weller 1978). Even less is known of optimum schemes to couple land and water systems or manage a complex of wetlands and uplands over a large area for maximum benefit to waterfowl. It is not so much that methods for manipulation are unknown, but rather that manipulation in the past has not been addressed in an experimental fashion so that the value of results can be quantified. Erskine (1987*b*) succinctly suggested "Habitat improvements should be conducted as planned experiments so as to demonstrate their effectiveness in meeting planned objectives." This seems to be an excellent maxim to apply to any management activity, but it has been seldom followed.

Is There a Local Problem?

The overall objective of the North American Waterfowl Management Plan—to increase the wintering population index of black ducks in the Atlantic and Mississippi flyways to 385,000 birds by the year 2000—is the result of a continent-wide assessment of the species' status that found numbers lower than desired and decreasing. The continent-wide effort to remedy this deficiency includes manipulations of habitat, manipulations of regulations of various kinds to limit the losses arising from man's actions, and strengthening of surveys to monitor the status of the species and progress toward the objective. Stepping the broad objective down to specific habitat, however, requires site-specific evaluation of current and potential black duck populations and a realistic assessment of the cost versus benefit of management action.

The first step in any management assessment is to determine whether or not an actual problem exists that can be rectified through application of available resources. In general, management action should be justified according to biological needs identified through intensive investigation; proposed practices should be evaluated for their effects on other natural resources and land uses; and the action should be economically practical with clear and attainable objectives.

Whether or not a local black duck population is optimum is a relative judgement that cannot be efficiently assessed if objectives are set solely through administrative order. If, however, the current status of the population is compared with historical records, conditions on nearby sites, and the general behavior of black duck populations throughout their range, then a biological judgement may be made on whether manipulation could be expected to provide benefits. The data provided in the tables of this report, for example, provide a start in this direction by way of comparative assessment. This means that before any management is begun, information must be obtained on current status of the population. This does not mean that one must rely on inconsistent and inappropriately collected data augmented by personal experience, but rather that scientifically sound information on numbers, distribution, fecundity, and survival must be obtained before the manager can decide where to apply resources. For example, nest densities may be high, but the population may be decreasing because of nest predation, low brood survival, factors extrinsic to the site such as heavy hunter harvest of local birds or loss of wintering habitat, or a combination of factors. The management response must be to attack causes, not simply to respond to symptoms. This requires that the population and habitat of interest be thoroughly known.

Selecting Priorities

In earlier sections, a host of potential management actions to benefit the black duck was listed. Although the advantages and disadvantages of each were discussed, it was impossible to rank the potential actions on the basis of probability of their success in increasing numbers of black ducks. This was because management that is not directed at critical limiting factors for a population will not have the desired effect—that is, it is necessary

first to know the problem before applying the solution. Generic solutions to be applied to all black duck breeding areas are thus a contradiction in terms and should not be sought. The choice of techniques to apply will always depend on the characteristics of the particular habitat and the dynamics of the local black duck population.

The most important portion of the waterfowl management equation on the breeding grounds is the production of young. All breeding grounds management is essentially designed to increase the probability of young birds successfully hatching and reaching flight age. In accomplishing this, the welfare of the adult female is also incorporated, because local production of young depends on females returning to the same areas each spring. Because the entire program for breeding waterfowl will collapse if survival is too low for nests, eggs, or young, and will likewise collapse if mortality of females is too high, initial management efforts should be directed to increase survival in each of these categories.

There is no direct evidence that a lack of habitat for breeding per se is a major problem for the black duck in the Atlantic Provinces (Erskine 1987*b*) or elsewhere. Lack of birds in many areas otherwise seemingly suitable for black ducks bolsters the argument that increases in production and survival of the current population in available habitat should be a priority. Thus, it is inefficient to initiate large-scale programs to develop new habitat before deficiencies in production on existing habitat are rectified. Attracting birds to habitat where nest or brood success is low has the immediate effect of lowering overall productivity below what it would be without management.

Protection and improvement of existing habitat to produce more waterfowl is properly the objective of black duck breeding grounds management instead of the more common focus on development of new habitat. After determining where survival of the black duck can be increased, one or several of the earlier discussed options for management can be chosen and applied with proper attention to evaluation of effect. If management is appropriately chosen, the population will respond over time, and ultimately other limiting factors will gain importance. This will present a new priority for management. The entire process remains dynamic and demands the constant attention of the manager.

Reaching and maintaining maximum populations of black ducks on an area is probably an artificial goal that cannot be addressed or even recognized when it is attained. It is far better to consider the process one of enhancing the landscape to provide maximum benefits for the black duck.

Evaluation of Populations and Habitats

Techniques for evaluation of populations and habitats are available in the literature, but unfortunately, a single guide to such activity has not been compiled. Some suggested references for particular applications are:

- **aquatic habitat assessment**—Hamilton and Bergerson (1984)
- **band recovery analysis**—Brownie et al. (1985)
- **coastal ecosystem management**—Clark (1977)
- **erosion and sediment control**—Goldman et al. (1986)
- **fisheries management**—Bell (1984)
- **habitat assessment** (general)—Cooperrider et al. (1986)
- **habitat management** (general)—U.S. Forest Service (1969); Payne and Copes (1986)
- **herbicide use**—Hansen et al. (1983)
- **impoundment management**—Knighton (1985*b*)
- **moist soil management**—Fredrickson and Taylor (1982)
- **nest studies**—Klett et al. (1986)
- **riparian assessment and management**—Platts et al. (1983); Platts et al. (1987)
- **soil and water engineering**—U.S. Department of Agriculture, Soil Conservation Service (1975)
- **upland habitat assessment**—Hays et al. (1981)
- **waterfowl census**—Gollop and Marshall (1954); Dzubin (1969); Hammond (1970); Reed (1975); Anonymous (1976); Kirby (1980); Longcore and Ringelman (1980); Rumble and Flake (1982)

• **waterfowl ecology**—Palmer (1976); Bellrose (1978)
• **waterfowl food plantings**—McAtee (1917); Martin and Uhler (1939)
• **wetland classification**—Cowardin et al. (1979)
• **wetland ecology**—Weller (1981); Mitsch and Gosselink (1986)
• **wetland habitat manipulation**—Addy and McNamara (1948); Linde (1969); Waterfowl Habitat Development and Management Committee, Atlantic Flyway Council (1972); Schnick et al. (1982)

The necessity to use the most efficient methods and to use sampling schemes that permit year-to-year comparison of data cannot be overemphasized. Sampling schemes and methods for manipulation of data are beyond the scope of this report, but are areas in which it is imperative to seek expert advice. Within the U.S. Fish and Wildlife Service, such assistance is available from Research and Development Centers and Cooperative Fish and Wildlife Research Units.

Monitoring Progress

Once management actions are initiated, it is incumbent on all parties, especially successive station managers, to monitor the progress of work and the response of the habitat and waterfowl populations to manipulations. Only in this way will it be possible to compare results with objectives, to determine economic and biological efficiency of the effort, and to develop means to improve the undertaking. An optimum list of information that should be recorded includes the following, but all stations will not be able to afford such intensive data gathering:

• waterfowl pair counts
• nest success rates
• brood density estimates
• brood survival rates
• water level records
• changes in vegetation distribution, abundance, and species composition
• response of other wildlife to habitat manipulation
• human use of the area

Cowardin et al. (1985, 1988) have shown how measurement of waterfowl recruitment parameters can be combined with estimates of annual survival rates and proposed manipulations of the environment in stochastic models. These models can predict population change that is independent of the breeding population size on an area and can evaluate the efficiency of alternative management techniques. The use of models to guide management is currently being implemented in Small Unit Management efforts experimentally applied in combined Northern Prairie Wildlife Research Center/Refuge management studies on several prairie Waterfowl Production Areas and Refuges (L.M. Cowardin, personal communication). This Small Unit Management approach has not yet been expanded to address areas outside the midcontinent waterfowl breeding areas where the majority of data on nesting waterfowl have been obtained (Cowardin et al. 1983). Nonetheless, the same approach seems capable of providing excellent guidance to managers in the eastern United States. The data of most use in evaluating waterfowl production on an area, and developing predictive models to assess management options, are those obtained from studies of nest success and brood survival rates. Because these data most relate to recruitment of birds, emphasis on these aspects of monitoring progress toward objectives seems the best approach for black duck managers, even in the lack of specific models to guide current management.

Additional data of use in assessment of the management effort include phenological notes on migration dates, ice-out and -in dates, etc.; photographic records of changes in habitat; detailed records of the extent of all habitat manipulations; and an ordered file of records of progress toward meeting the objectives of management action. Throughout, it must be remembered that the purpose of monitoring is to obtain information on progress toward objectives. Therefore, adequate (but not excessive) evaluation is necessary.

Integrating Research and Management

Often, research and management are considered entirely different aspects of the biological program. In reality, they are complementary means to address natural

resource issues, and efficiency of management can be much increased by early integration of research efforts in the management program.

Managers should make every attempt to solicit participation in station programs from nearby university faculty and students, Cooperative Fish and Wildlife Research Unit personnel, State Game and Fish personnel, and scientifically inclined local groups and residents. These parties can assist in census and monitoring schemes, studies of particular species, and evaluations of management results. In most circumstances, it is best to meet with potential cooperators personally, and to provide a list of questions the station would like to have addressed. In some cases, it is also necessary for the manager to prepare a statement of work (draft proposal) concerning the project to clearly define important issues and to set timetables and interim objectives for the needed investigation. Although not all questions can be addressed, and some remote stations may have difficulty obtaining cooperators, persistence pays off, and the aggressive manager can ultimately enlist substantial cooperation. Assistance in preparing lists of research questions, evaluating research proposals, and reviewing research products may be obtained from the Office of Information Transfer, Research and Development (see title page).

Conclusions

Throughout, management for black ducks should be designed to meet the specific seasonal needs of the species. This means that concentration of management effort toward breeding habitat improvement should be to meet the needs of pairs, nesting females, and broods. To reiterate the main thrust of the first section, this requires providing isolation for the pairs, high quality foods, and appropriate nesting and brood-rearing cover.

It is not necessary that the requirements for the entire breeding period be met by a single tract. Management of a complex of wetlands and uplands is a far better approach. Toward this end, Mendall (1949*b*) suggested locating managed areas near unmanaged habitat to take advantage of the benefits of a complex of habitats.

Choice of locations to manage is important. Spencer (1968) suggested maintaining a maximum number of appropriate areas rather than a maximum total area. In general, the black duck benefits from nest cover dispersed over broad areas (Stotts and Davis 1960) and patches or mosaics are better than linear tracts (Reed 1973*b*). A complex of wetlands is more likely to fulfill seasonal food needs of waterfowl than any single wetland, no matter how intensively the latter may be managed. Females and broods need high quality food which is best found as aquatic invertebrates (Swanson and Meyer 1973; Krapu 1979; Reinecke 1977, 1979; Owen and Reinecke 1979; Reinecke and Owen 1980). Ducklings feed almost entirely on invertebrates for the first weeks of their lives (Mendall 1949*b*, 1973; Sugden 1973; Reinecke 1979).

As emphasized by Reed (1973*b*), diversity of habitats is also important: management must not confine efforts to attempts to provide "foolproof" nesting structures or preferred cover. It is important, however, that appropriate cover be available early, because early clutches are larger (Stotts and Davis 1960) and renesting is seldom entirely successful.

Management should be a response to identified limiting factors for local populations. Investigations to determine the adequacy of quantity and quality of habitat, interrelations with other species, and the specific demographic characteristics of the local population are not only a prerequisite to management action, but an ongoing concern of all black duck management.

Finally, every attempt should be made to integrate management on specific lands with that of nearby Federal areas, State management areas, and private lands. It is perhaps through demonstration of appropriate management techniques on a Refuge—and subsequent influence on others—that management of black duck breeding habitat on Service lands can have its most profound effect.

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Appendix: Scientific and common English names mentioned in the text

Scientific and common names in the text have been standardized insofar as possible, that is, all names used in original works and referenced herein have been revised to meet current practice. With few exceptions, scientific and common names are taken from Collins et al. (1978) for amphibians and reptiles, American Ornithologist's Union (1983) for birds, Sutherland (1978) for invertebrates, Jones et al. (1982) for mammals, and Scott and Wasser (1980) for plants. The only exceptions occur in the naming of several plants where common practice in wetland ecology assigns a different common name than that supplied by Scott and Wasser (1980).

Common	Scientific
bass	*Micropterus* spp.
beaver	*Castor canadensis*
blackberry	*Rubus* spp.
blueberry	*Vaccinium* spp.
bowfin	*Amia calva*
budworm, spruce	*Choristoneura fumiferana*
bulrush	*Scirpus* spp.
bulrush, Olney	*Scirpus olneyi*
burreeds	*Sparganium* spp.
bush, hightide	*Iva frutescens*
carp, common	*Cyprinus carpio*
cordgrass	*Spartina* spp.
cordgrass, smooth	*Spartina alterniflora*
cordgrass, marshhay	*Spartina patens*
crow, American	*Corvus brachyryhnchos*
crow, fish	*Corvus ossifragus*
duck, American black	*Anas rubripes*
ducks, dabbling	*Anas* spp.
eel, American	*Anguilla rostrata*
fir, balsam	*Abies balsamea*
fly, black	*Simulium anatimum, S. ruggelsi*
fox, red	*Vulpes vulpes*
grass	Gramineae
gulls	Larinae
grackle, common	*Quiscalus quiscula*
hay, salt	*Spartina patens*
hemlock	*Tsuga* spp.
heron, great blue	*Ardea herodias*
honeysuckle, Japanese	*Lonicera japonica*
leatherleaf	*Chamaedaphne* spp.
leatherleaf, Cassandra	*Chamaedaphne calyculata*
leucocytozoan	*Leucocytozoan simondi*
loosestrife, purple	*Lythrum salicaria*
mallard	*Anas platyrhynchos*

Common	*Scientific*
mink	*Mustela vison*
mosquito	*Aedes* spp., *Anopheles* spp., *Culex* spp.
mosquito, saltmarsh	*Aedes solicitans*
mosquito, brown saltmarsh	*Aedes cantator*
muskrat	*Ondatra zibetheca*
naiads	*Najas* spp.
needle rush	*Juncus roemerianus*
nutria	*Myocastor coypus*
Olney bulrush	*Scirpus olneyi*
opossum, Virginia	*Didelphis virginiana*
osprey	*Pandion haliaetus*
owl, great horned	*Bubo virginianus*
panicum	*Panicum* spp.
pheasant, ring-necked	*Phasianus colchicus*
pickerel, chain	*Esox niger*
pickerelweed, common	*Pontederia cordata*
pike, northern	*Esox lucius*
pine, jack	*Pinus banksiana*
pine, white	*Pinus strobus*
poison-ivy, common	*Toxicodendron radicans*
pondweeds	*Potamogeton* spp.
raccoon	*Procyon lotor*
rat, Norway	*Rattus norvegicus*
reedgrass, bluejoint	*Calamagrostis canadensis*
rush	*Juncus* spp.
rush, needle	*Juncus roemerianus*
saltgrass, seashore	*Distichlis spicata*
sedge	*Carex* spp.
skunk	*Mephitis mephitis*
smartweeds	*Polygonum* spp.
snake, black rat	*Elaphe obsoleta*
snake, fox	*Elaphe vulpina*
spiraea	*Spiraea* spp.
spruce	*Picea* spp.
spruce, white	*Picea glauca*
terns	Sterninae
trout	*Salmo* spp.
turtle, snapping	*Chelydra serpentina*
watershield, Schreber	*Brasenia schreberi*
waxmyrtle, sweetgale	*Myrica gale*
weasel	*Mustela* spp.
wildrice, annual	*Zizania aquatica*
widgeongrass	*Ruppia maritima*
white-cedar, northern	*Thuja occidentalis*
woodcock, American	*Scolopax minor*

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16. Abstract (Limit: 200 words)

This paper provides a source document for American black duck (Anas ruripes) management planning throughout the Northeast. In three sections, the text presents highlights of a literature review from the perspective of prescribing specific management action for the breeding grounds of the American black duck. The text first reviews what is known of the breeding habitat requirements of American black ducks in the Northeast, with separate sections on habitat use by breeding pairs, selection of nest sites, and habitat use by broods. Options for managing American black duck breeding habitat are discussed under two headings: Habitat Improvement, and Reduction of Mortality and Competition. A final section provides suggestions on implementing management. Sources of additional information are provided as is an extensive literature cited section. The text is not intended to be a "manual" for waterfowl management, but sufficient references are included to permit further review of all aspects of American black duck breeding ecology and each of the mangaement techniques discuused.

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